The Journal of
Bone and Joint Surgery

LORD NUFFIELD

Great Benefactor of Orthopaedic Surgery

Eightieth Birthday

William Richard Morris was born eighty years ago and wanted to be a doctor, but the costs of medical education could not be met; so he was apprenticed to a bicycle shop in Oxford. He left at the age of sixteen because his request for a rise in wages of one shilling a week was refused, and he set up his own shop for making bicycles with a working capital of four pounds. From this humble start Morris became Lord Nuffield of Nuffield in the County of Oxford—the greatest benefactor of orthopaedic surgery, child health and anaesthesia that the world has ever known. In promoting the development of orthopaedic surgery in England and Northern Ireland, South Africa, New Zealand and Australia—in which country he always had such faith—he has given more than twenty-nine million pounds to hospitals, colleges, orthopaedic services, scholarships, professorships, residential colleges for young overseas surgeons, departments of anaesthesia, research laboratories and after-care orthopaedic services.

It is breathtaking, exhilarating and inspiring that a youngster with a capital of four pounds should within his lifetime have been capable of giving, and willing to give, to orthopaedic surgery and medicine almost thirty million pounds.

Nuffield always had courage and was never daunted by risks. Though nervous and sensitive he was always sure of himself. Decisions once taken were announced firmly and promptly. After one management discussion he was asked tentatively to make known his decision as soon as possible so as to allow an early start. He looked at his watch and said: " It is five to twelve; if you want to make a quick start you can start at twelve o'clock."

Nuffield is capable of considerable anger, especially in response to laziness; but however angry he may sometimes have been the storm always blew over and was soon forgotten. It is a great quality to be angry when the occasion arises but thereafter to forget it promptly. One other attitude that I cherish was his reply to those who urged him to worry less, when he would say: " Without worry you can never get anywhere."

His genius in manufacturing motor cars is reflected in his recreations. He regularly repairs the clocks of which his collection is so valuable, and the cigarette lighters on which he is an expert. In his dressing room there is a big wardrobe, the inside of which has been converted to a tool-bench with vices and drills. He can shut the doors as if in any dressing room—or open them and work at his jobs.

He is a friendly and quiet man, reserved, reticent and shy, with thick hair brushed straight back, lined brows, happy eyes and a determined chin. He does not enjoy banquets or evening dinners; but on his eightieth birthday he did go to the Centenary dinner of the Royal Society of Medicine when he was elected to Honorary Fellowship—one of the many he has received. He is a Freeman of six cities in England and Wales, Knight in the Order of St John of Jerusalem, honorary graduate of eight Universities in England, Northern Ireland and Australia, Honorary Fellow of the Royal College of Surgeons of England and Gold Medallist of that College—an honour conferred only thirty times in the last century.

COWLEY,
OXFORD.

10th October, 1957.

Dear Sir Reginald

Thank you so much for your telegram of good wishes for my birthday.

I am deeply touched that this issue of the British Volume of the Journal of Bone and Joint Surgery is dedicated to me, and am appreciative indeed of this generous gesture to commemorate my 80th birthday.

I can assure you that I have always considered it a wonderful privilege to have been able to help in the great work of orthopaedic surgery.

Sincerely yours,

Sir Reginald Watson-Jones, Kt., F.R.C.S.

His sense of humour is reminiscent of the happy and sometimes boisterous Robert Jones. On one occasion, before he had started making cars, he gave a lift in his recently bought smart coupé to a friend who said on arrival at his home: " You must come in because otherwise my wife will think I have come into a fortune," and he replied promptly " Tell her that you have just got out of one." Again, when a report of his achievements had been read to him he said " The man's a marvel," but with a chuckle, twinkle and with utmost modesty.

In 1904 this young bicycle-maker married a quiet and retiring lady, Elizabeth Maud, who has been his close and stimulating companion throughout his life. They have no children of their own but it has been said with much truth that " Nuffield made the whole nation his heir." His home is a quiet retreat which he says " recharges my batteries."

On his eightieth birthday the orthopaedic surgeons of Great Britain, the British Commonwealth of Nations and the United States of America pay humble respects and grateful acknowledgment to our friend, supporter and benefactor—Nuffield. EDITOR.

TREATMENT OF CONGENITAL DISLOCATION OF THE HIP

The paper by Somerville and Scott of Oxford in this issue is in keeping with the modern trends in treatment of congenital dislocation of the hip; there is an increasing tendency towards operation, because the long-term results of conservative management have not proved satisfactory. The percentage of satisfactory final results has varied in recorded series from approximately 50 per cent down to 11 per cent (Severin), although in those aged less than three years the proportion is slightly better. It is realised that the condition is a true dysplasia and that subluxation or luxation is but a part of the pathology; it is also appreciated that a treated hip with good function may not retain its function over the years if an appreciable anatomical blemish is present. Obviously the ideal aim is a perfect anatomical and functional result with the least expenditure of effort and time and with the greatest safety.

In general the treatment of congenital dislocation of the hip in the child under five years involves two main hurdles: 1) the concentric reduction of the femoral head into the acetabulum; and 2) its permanent retention there, which can be achieved only by the development, natural or assisted, of the acetabular roof and the correction of any deforming factor such as anteversion of the femoral neck with or without valgus deformity. Some dislocated hips are irreducible by closed methods. The necessary open reduction is best carried out forthwith rather than after several unsuccessful attempts at closed reduction. The causes of irreducibility are chiefly soft-tissue obstructions, and these have been well described by Putti (1935) and more recently by Platt (1956). The latter laid more emphasis on a hypertrophied ligamentum teres and a large femoral head than on abnormal attachment of the capsule to the femoral neck and the presence of an adherent plug of fibro-fatty tissue in the acetabulum. These latter two structures, in the writer's experience, are a more common finding. An hour-glass contraction of the capsule is no longer conceded, but undoubtedly a contracted ilio-psoas tendon often indents the capsule and may, by itself, be the most important obstacle to reduction. The inverted limbus (acetabular labrum), although it may be a contributing factor in preventing reduction, is not in itself of major importance. How then can the view put forward by Somerville and Scott in their important contribution to this Journal be reconciled with these findings at operation? Reduction implies that the femoral head enters the acetabulum, but it may be placed concentrically or eccentrically. It appears that excision of part or all of the limbus, as advocated, allows an eccentric reduction to be converted easily and safely to a concentric one. It should be emphasised that a truly irreducible dislocation, in which the head will not descend to the level of the acetabulum or enter it, can never be reduced by the simple means of removing the inverted limbus.

Arthrography has proved reliable, but it is not essential in the management of congenital subluxation or dislocation. Its employment can give valuable information about the size of

the cartilaginous femoral head, the soft-tissue disposition, and whether a given reduction is concentric or eccentric. It should not be used routinely, but should be restricted to the few occasions on which information is necessary about the position or the size of the cartilaginous head in relation to the acetabulum. In arthrography an anterior approach seems to find favour with most orthopaedic surgeons, but the writer has found the perineal route much easier.

A common finding at operation in an older child whose acetabular roof has not developed in spite of an apparently satisfactory reduction has been the presence of a compressed, inverted limbus between the head and the acetabular roof. Is it not conceivable that the presence of this inverted limbus through the years has interfered with the natural ossification of the acetabular roof? Somerville and Scott think so and produce some radiographic evidence in favour of their hypothesis; it appears that removal of a fair sized inverted limbus in the younger child allows better development of the acetabular roof. Will excision of the limbus therefore make the operation of acetabuloplasty unnecessary in the young child? This may be so except on the rare occasions when an open reduction is found to be unstable because of acetabular deficiency or a large femoral head cannot be covered by the acetabulum. If the disproportion between the femoral head and acetabulum is excessive an operation in two stages is sometimes useful: first implantation of bone in the ilium above the hip, and then, three months later, fashioning the acetabuloplasty. In the older child acetabuloplasty will still be necessary when instability and the danger of redislocation is due to a sloping acetabular roof.

Epiphysitis of the femoral ossific nucleus unfortunately occurs all too often; severe degrees often mar the final result. It has never been satisfactorily explained. Many hypotheses contain an element of truth, but not one contains the whole truth. The epiphysitis has been considered to be part of the dysplasia, but this does not explain why it sometimes occurs in the opposite, undislocated hip. Manipulative reduction has been incriminated, and may well be a contributory (but not the main) factor because the incidence of epiphysitis has lessened, but by no means disappeared, with the use of more gradual methods of reduction by traction. Epiphysitis appears to be less frequent after open reduction, and it may well be that removal of the soft tissue including the inverted limbus allows the femoral head to be placed in the acetabulum with less tension than occurs in a closed reduction.

Anteversion of the femoral neck and its significance as a cause of redislocation have long been recognised, but, in this country particularly, its correction has been considered necessary only within the last twenty years. According to Le Damany (1908) and Badgley (1949), the primary cause of the dislocation is an anteversion of the femoral neck, and all soft-tissue abnormalities are secondary. Many would disagree. It is not possible clinically to measure with any accuracy the amount of anteversion; that is not important provided that the presence of anteversion is recognised and its adequate correction by osteotomy of the femoral shaft undertaken. The method described by Somerville and Scott has been carried out for a longer time in other orthopaedic centres in this country, although not routinely. Recurrence of anteversion requiring further operative treatment may rarely occur.

Valgus deformity of the femoral neck, if present, can and should be corrected by wedge resection at the time of the osteotomy. That procedure enables the femoral head to occupy a concentric position in relation to the rest of the pelvis.

After the age of three it is doubtful whether conservative treatment is worth a trial. Between the ages of three and eight a subluxation should be dealt with by closed reduction, which is generally easily performed, followed by acetabuloplasty with, if need be, correction of any anteversion. A true dislocation, between the ages of three and five would require open reduction, but between the ages of five and ten a dislocation is best dealt with by a capsular arthroplasty along the lines advocated by Hey Groves (1928) and modified by Colonna (1936).

Conservative treatment has had a long trial; it " has not produced the goods "; its era is slowly passing and will be replaced eventually by the routine operative treatment of congenital

dislocation of the hip. Satisfactory results in a much larger percentage of patients should be obtained—and with a much shorter duration of treatment—than by purely conservative measures.

DAVID TREVOR.

REFERENCES

BADGLEY, C. E. (1949): Etiology of Congenital Dislocation of the Hip. Journal of Bone and Joint Surgery, **31–A,** 341.

COLONNA, P. C. (1936): An Arthroplastic Operation for Congenital Dislocation of the Hip—a Two Stage Procedure. Surgery, Gynecology and Obstetrics, **63,** 777.

GROVES, E. W. Hey (1928): The Treatment of Congenital Dislocation of the Hip-Joint, with Special Reference to Open Operative Reduction. *In* The Robert Jones Birthday Volume, p. 73. London: Humphrey Milford Oxford University Press.

LE DAMANY, P. (1908): Die angeborene Hüftgelenksverrenkung. Ihre Ursachen—Ihre Mechanismus—Ihre anthropologische Bedeutung. Zeitschrift für Orthopädische Chirurgie, **21,** 129.

PLATT, Sir H. (1956): Congenital Dislocation of the Hip: the Rôle of Open Reduction. *In* Modern Trends in Orthopaedics (Second Series), p. 93. Edited by Sir H. Platt. London: Butterworth & Co. (Publishers) Ltd.

PUTTI, V. (1935): Anatomia della Lussazione Congenita dell'Anca. Bologna: L. Cappelli.

SEVERIN, E. (1941): Contribution to the Knowledge of Congenital Dislocation of the Hip Joint. Late Results of Closed Reduction and Arthrographic Studies of Recent Cases. Acta Chirurgica Scandinavica, **84,** Supplementum 63.

THE MAINTENANCE OF TRAUMATIC ARTERIAL SPASM

An interesting paper by A. Benjamin in this issue of the Journal again discusses the idea that oedema in swollen muscles is an important factor in the pathology of traumatic arterial spasm and therefore in the production of Volkmann's ischaemic contracture. Benjamin does not blame oedema for causing the arterial obstruction which precedes the contracture, nor does he blame oedema *at the site of the fracture* for maintenance of the spasm; he suggests instead that " tension from oedema in a *neighbouring* fascial compartment may be the stimulus that maintains the spasm." He therefore advises wide decompression of swollen muscles away from and distal to the site of the fracture, in the hope that this will help to overcome the spasm by removing one factor which keeps it up. In support of this view he describes three cases, in each of which exploration of injured limbs some hours after the injuries demonstrated the presence of oedema in distal muscles and in which, he claims, decompression of that oedema helped in the restoration of the arterial circulation.

This suggestion cannot, of course, be disproven. It therefore must not be rejected. Readers will, however, decide for themselves whether or not the idea is adequately supported by Benjamin's evidence. His first patient showed the well known and welcome phenomenon of relaxation of arterial spasm during an operation. The fact that this relaxation occurred immediately after division of deep fascia distal to the occluded artery does not, of course, imply a casual relationship, nor does Benjamin postulate any mechanism, reflex or other, by which such a cause could operate. In his second case, is it quite fair to attribute the recovery of the circulation to the muscle decompression? The artery relaxed twenty-five minutes later, and after several other manipulations had been employed. The third case, in which the affected artery was not seen and in which the systemic blood pressure was not recorded, can hardly be regarded as a source of conclusive evidence.

So the debate must continue. Benjamin may be right; further evidence will show. Let us, however, beware of attractive theories which may perhaps be accepted because they cannot be rejected. Surgery has been led astray too often by just this fallacy.

D. LL. GRIFFITHS.

ARTHROPLASTY OF THE HIP

R. A. DENHAM, PYRFORD and CHERTSEY, ENGLAND
and
W. ALEXANDER LAW, LONDON, ENGLAND

During the last four years a review of 211 hip arthroplasties performed by various surgeons in different parts of the country has been compiled by one of us (R. A. D.). The aim of the investigation was to discover if there were any factors that were frequently associated with success or failure of this operation. This paper summarises some of the results of this work; it includes some technical details of the operative approach that has so far achieved the highest percentage of success.

MATERIAL AND GENERAL INFORMATION

A number of factors in each patient's pre-operative, operative and post-operative phases have been tabulated for analysis. The probable causes for success and failure have been found by comparing these factors in the excellent, good and bad results.

None of the 211 cases included in the statistical series was observed for less than twelve months after operation. The average post-operative period was fifty-nine months in the case of the Smith-Petersen moulds, and twenty-five months in the case of the Judet prostheses. There was a 94·7 per cent attendance for the follow-up examination. Cases were consecutive; there was no " selection " of cases. All percentages recorded in tables and illustrations are percentages of 211 cases of hip arthroplasty.

A new method was used to classify results. It is submitted that this classification gives a more accurate assessment of results than do other methods in current use. In the analysis which follows, groups of excellent (E), good (G) and bad (B) results are compared (Table I).

TABLE I
CRITERIA USED IN ASSESSING AND CLASSIFYING THE RESULTS OF ARTHROPLASTY

Result	Factors considered in assessment of result			
	Pain	Opinion	Movement	Function
1 Excellent = E	"None"	Satisfied with result	Good	Good
2 Good = G	"A little," "Very occasional"	Satisfied with result	Good	Good
3 Bad = B	"A lot of pain"	Dissatisfied with result	Good or bad	Good or bad
4 Intermediate groups—Combinations of these four factors				

Analysis is a tricky weapon with which to attack a human problem, for the variable factors are many, and the patients relatively few; however, we do hope to show that there are only four factors which greatly influence the result of an arthroplasty.

Selection of cases for operation—Patients should be selected for operation mainly on account of pain. If they cannot sit, sleep or walk in comfort because of pain, surgical treatment should certainly be considered. If the patient is young, has a normal hip on the opposite side and no other joint involvement, an arthrodesis is usually preferred. If he is older and his general condition is satisfactory an arthroplasty may be considered. A limp, fixed deformity or a

poor range of movement alone are not grounds for arthroplasty, but are to be considered in conjunction with pain, which must always be the principal indication for operation.

Femoral neck fractures, ankylosing spondylitis and congenital dislocation of the hip present special and complicated problems. Their treatment is not discussed in this paper.

FACTORS THAT APPEAR TO HAVE LITTLE INFLUENCE ON THE RESULT OF AN ARTHROPLASTY

Age—Comparison of the average ages in cases of osteoarthritis in the excellent, good and bad results shows that there is very little difference between the three. Therefore, no patient with osteoarthritis should be denied operation only on account of his age, provided he is otherwise fit (Fig. 1).

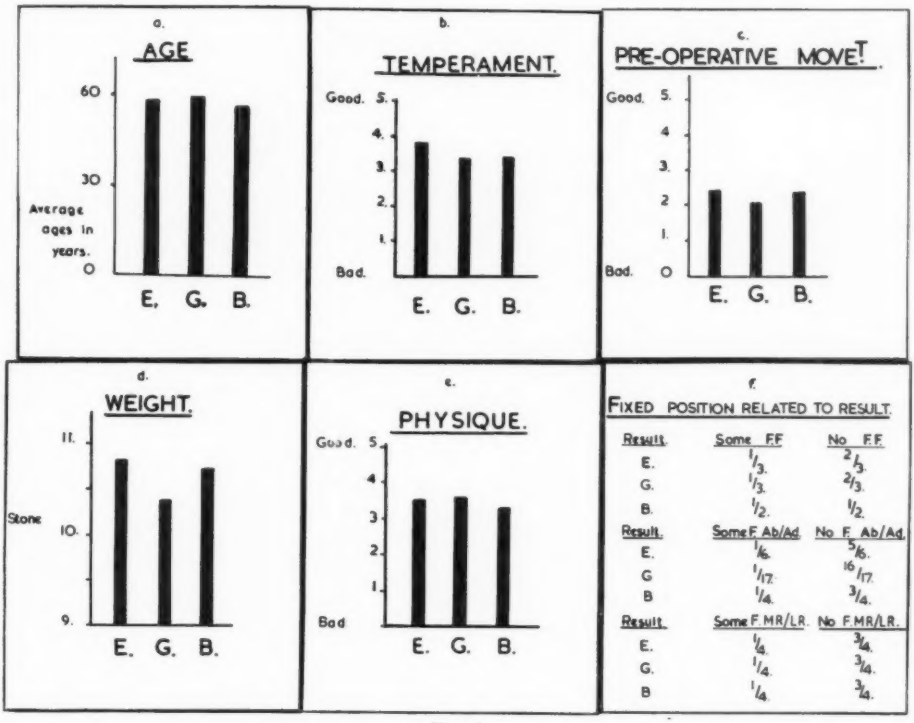


FIG. 1

In these diagrams averages are compared in the excellent (E), good (G) and bad (B) results. These six factors appear to play only a small part in the result of an arthroplasty. Note: In f, F.F denotes fixed flexion, F.Ab/Ad denotes fixed abduction or adduction, and F.MR/LR denotes fixed medial or lateral rotation.

Temperament—At the follow-up examination points were given out of a possible five in an attempt to correlate mental make-up with results. The strong, stoical, courageous character was given high marks. The object of this investigation was to find out if it would be fair to advise that an arthroplasty should be done only in patients who were strong in character, with the fortitude necessary to benefit from the early programme of post-operative exercises. Would it be correct to blame the patient's " psyche " for a bad result? Figure 1 shows that the mental make-up of the patients in the excellent, good and bad results was similar; there is little difference between the average figures. It is recognised that assessment is a matter of

personal judgment rather than scientific measurement, and the difficulty of estimating this factor correctly is obvious. The failure of an arthroplasty is such a major disaster that the value of these figures must be small. Nevertheless, in this series of cases analysis suggests that the patient's mental make-up plays only a small part in the result of an arthroplasty.

Hip movement before operation—Comparison between the three groups of results was made when pre-operative movement had been given points out of a possible five. The results indicate that this is not a factor of great importance. Poor movement before operation may be followed by a good post-operative result, and the converse also applies (Fig. 1).

The patient's weight—No records of the patient's weight before operation were available. Weights were recorded after operation. Despite the fact that a patient who has a bad result would lead a more sedentary life, the difference between the average weights was only 9 per cent. There were many excellent results in patients weighing over 14 stones. Fat patients present technical difficulties at operation, but analysis shows that the result of an arthroplasty has little relation to the patient's weight (Fig. 1).

Physique—The patient's height and weight must be considered in relation to the power of his muscular system. One person who weighs 14 stones may be slim and powerful, whereas another patient of the same weight may be fat and flabby. The estimated strength of a patient in relation to his body weight was assessed out of a possible five. A strong light person would receive five out of five points. Figures show that patients with satisfactory results have only a slightly higher index than those with bad results (Fig. 1).

Fixed deformity after operation—In this series it appears that the result after operation was not related to fixed deformity (Fig. 1).

Conclusion—All these factors do play a part in the result of an arthroplasty, and in summation they may be worth considering, but their part is small when compared with the factors that follow.

FACTORS THAT APPEAR TO BE OF GREAT IMPORTANCE IN THE RESULT OF AN ARTHROPLASTY

The operation—It is submitted that the operation itself contains all the factors of supreme importance. There are various technical procedures which have to be performed, and there are various manoeuvres which have to be avoided. With these factors correctly observed, and with normal operative skill, success is probable. Without these factors, even superlative pre-operative, operative and post-operative treatment is liable to end in failure.

TABLE II

RESULT RELATED TO SURGICAL APPROACH

Anterior Smith-Petersen approach 127 cases	Lateral approach with trochanteric osteotomy 46 cases
24·4 per cent classified as excellent results	10·8 per cent classified as excellent results
29·5 per cent classified as good results	23·9 per cent classified as good results
4·7 per cent classified as bad results	26·0 per cent classified as bad results
41·4 per cent classified in other intermediate groups	39·3 per cent classified in other intermediate groups

The surgical approach to the hip joint—The anterior Smith-Petersen approach (1939) was used in 60·2 per cent of the cases in this series. The lateral approach with trochanteric osteotomy, upward displacement and subsequent reattachment of the greater trochanter with wire, catgut or screw was used in 21·8 per cent of cases. In the remaining 18 per cent of cases other types of incision had been used. Results in 127 cases performed with the anterior approach are compared with the results in forty-six cases in which the lateral approach with trochanteric osteotomy was used (Table II). Analysis shows that after the anterior Smith-Petersen approach

the proportion of excellent results was more than twice that after other incisions, and the proportion of bad results less than one-fifth: when the anterior incision was used 53·9 per cent of the cases were classified as presenting excellent or good results, and only 4·7 per cent were classified as presenting bad results. Table III summarises the results from two orthopaedic centres where the anterior Smith-Petersen approach had been used throughout; the results are very similar.

TABLE III

COMPARISON OF RESULTS AT TWO CENTRES USING ONLY THE ANTERIOR SMITH-PETERSEN APPROACH

	Centre A	Centre B
Total number of cases .	60	51
Excellent results . .	30 per cent	26 per cent
Good results . . .	31 per cent	28 per cent
Bad results . . .	0 per cent	2·3 per cent
Other intermediate groups	39 per cent	43·7 per cent

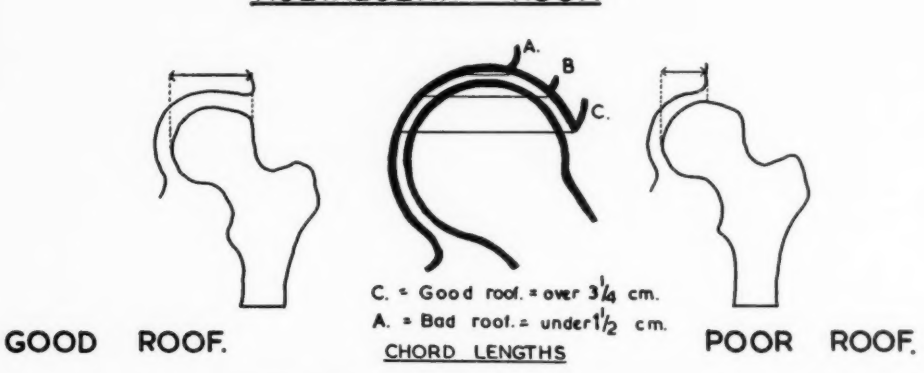
After the lateral approach with trochanteric osteotomy 26 per cent of the patients were dissatisfied with the result, for they still had pain and poor function, and in some instances this was worse than before operation. In approximately three-fifths of these failures a second major operation had to be performed within two years because local injections, radiotherapy, hydrocortisone, physiotherapy or the removal of the wires or screws from the greater trochanter had failed to relieve the pain. Naturally the results two to four years after operation were better than those assessed after one or two years, because by this time only 10 per cent of the unsatisfactory arthroplasties were still arthroplasties. In the other 16 per cent the patients had been subjected to a further operation such as arthrodesis, pseudarthrosis or displacement osteotomy. Hence the apparent improvement in the group. Of the remaining patients operated upon with trochanteric osteotomy 34·7 per cent gained excellent or good results.

It must be stressed that it is the interference with the bone of the greater trochanter that is thought to be one of the principal causes of failure. Arthroplasty through the lateral approach combined with either the muscle-cutting exposure (Gibson 1950) or the muscle-slide exposure (McFarland and Osborne 1954) was followed by good results in the nineteen patients who have been examined. However, a consistent disadvantage of these approaches seemed to be that a positive Trendelenburg's sign persisted longer after this operation than after the Smith-Petersen approach.

The acetabular roof—A good and a poor acetabular roof are illustrated in Figure 2. In all arthroplasties the acetabular roof was measured on the antero-posterior radiograph and these measurements were compared in the cases with excellent, good and bad results. Figure 3 shows that in the cases with excellent results a measurement of over $3\frac{1}{4}$ centimetres was found almost twice as often as in those with bad results; in the cases with bad results a reading of under $1\frac{1}{2}$ centimetres was five times as common as in those with excellent results. However, if we go a stage further, comparing the roof measurement in the excellent, good and bad cases after the anterior approach has been used, with similar measurements in the excellent, good and bad results after the lateral approach with trochanteric osteotomy we find that the surgical approach is more important than the roof measurement. Figure 4 shows how rapidly the force per unit area (pressure) rises as the chord length (acetabular roof) diminishes. Figure 5 demonstrates the degree of inward displacement and consequent increase in roof measurement that can and should be achieved.

The prosthesis or interposition substance—The best results were obtained when a Smith-Petersen Vitallium mould was used. In this series eleven out of eighty-nine Judet prostheses (ten acrylic and one metal) broke. The average time from operation to breakage was under eighteen months. The average period of observation after operation in all cases was twenty-five months.

Post-operative complications—If the eleven breakages of the Judet prosthesis are excluded there were few post-operative complications in this series of 211 patients. (Joint pain is not included as a " complication " of arthroplasty; pain means a " failure " of arthroplasty and



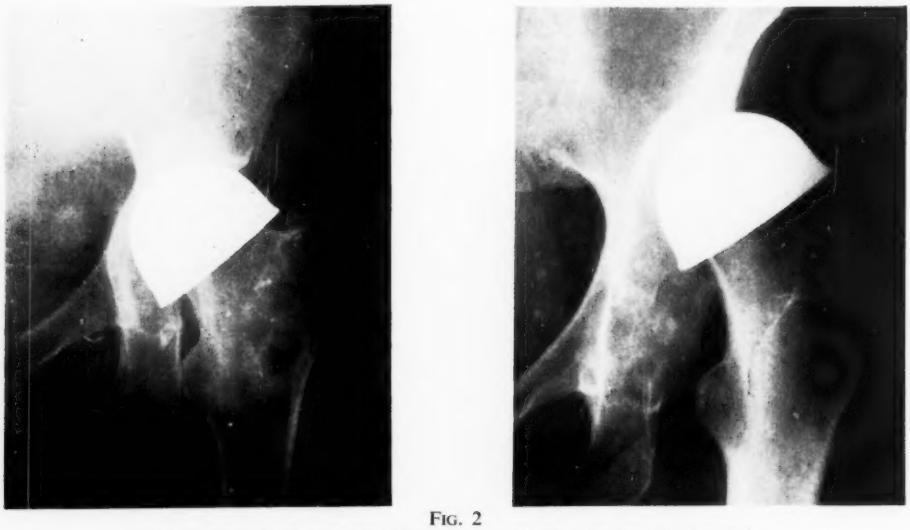


FIG. 2

Diagrams and radiographs illustrating a good and a bad acetabular roof.

is the main factor used in determining the quality of the result.) There were two early deaths from paralytic ileus, one death from haemorrhage from a gastric ulcer in the fourth week, and one from a massive pulmonary embolus in the sixth week; the mortality rate was therefore 1·8 per cent. Two moulds and two Judet prostheses had to be removed because of persistent sepsis. Dislocation of the mould or prosthesis occurred on six occasions; in every case there had been inadequate deepening of the acetabulum. Deep femoral thrombosis with oedema of the leg was observed in six cases. A persistent post-operative foot drop was seen on three

occasions. A small pulmonary embolus occurred in five patients, minor wound infections seven times, and haematoma of the wound in a total of seven cases. In the early post-operative period there were four times as many complications after the anterior incision as after the

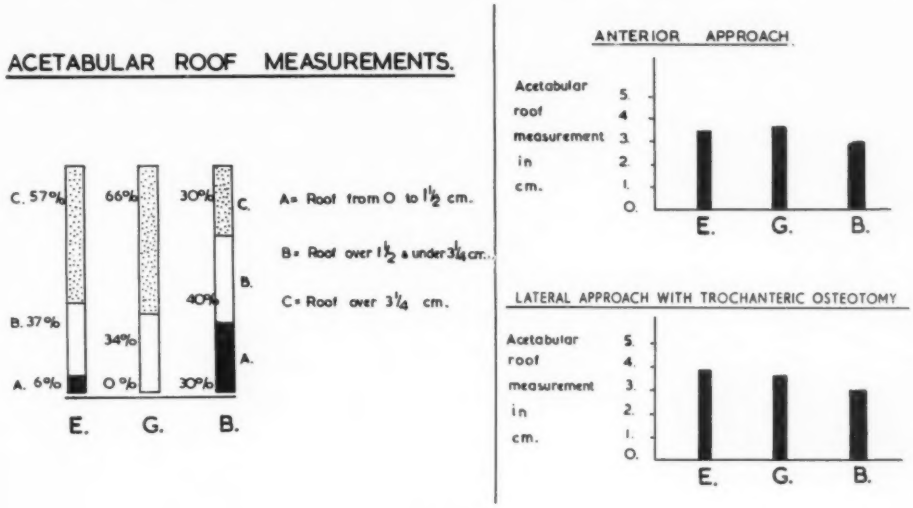


FIG. 3

This diagram illustrates that in the excellent (E) results an acetabular roof measurement of over 3¼ centimetres occurred almost twice as frequently as in the bad (B) results; in the bad results a reading of under 1½ centimetres was five times as common as in the excellent results. The relationship of approach to acetabular roof is also illustrated.

lateral. It is possible that many of these complications were due to excessive retraction of the femoral vessels at operation, or to inadequate haemostasis. Thus, unless the anterior approach is correctly done, there are dangers; but the dangers in the early phase are well compensated by the success of this approach in later phases.

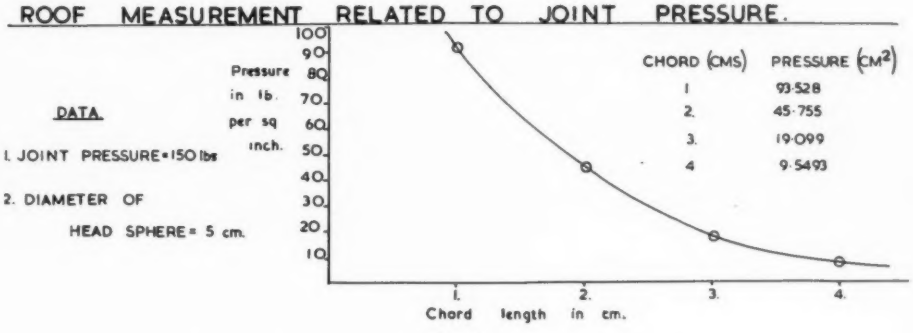


FIG. 4

Diagram to illustrate the relationship between roof measurement and joint pressure.

Late results in a personal series of sixty cases (W. A. L.)—All patients who lived within 100 miles of London and who were operated upon between 1948 and 1949 were asked to attend for follow-up examination. Sixty out of sixty-six patients attended.

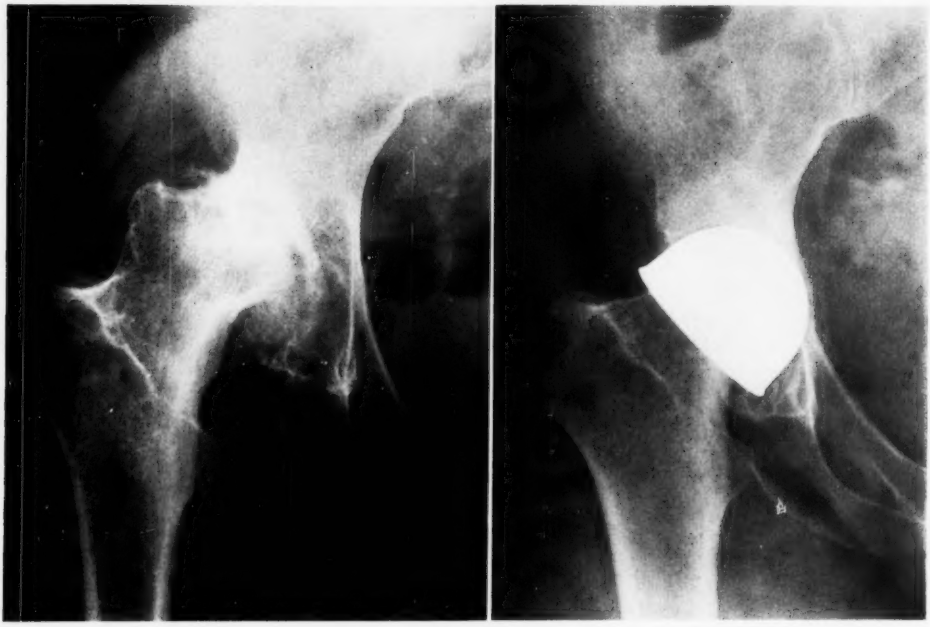


FIG. 5
Radiographs showing the amount of medial displacement and consequent acetabular roof formation that can and should be achieved.

Diagnosis—The reason for the arthroplasty was: osteoarthritis (fifty cases); congenital subluxation of the hip (four cases); ankylosing spondylitis (six cases).
Operation—All arthroplasties followed the pattern described later in this article.
Results—The result was excellent in 30 per cent, good in 31 per cent and fair in 39 per cent. None was classed as bad.
Complications—There was no death and no case of infection. The complications included: haematoma (five); subluxation of the mould (two); small pulmonary embolus (two); and troublesome post-operative shock (two).

SOME POINTS OF IMPORTANCE IN THE OPERATIVE TECHNIQUE

The technique of the operation has already been described in detail by Smith-Petersen (1948) and by Law (1952), but certain details and slight modifications based on increasing experience of the operation are well worth stressing.

The anterior Smith-Petersen approach reaches the hip joint from above as well as in front. Releasing the iliacus freely on the inner side of the iliac crest allows full and valuable medial retraction of the iliopsoas tendons and muscles. It is not necessary to strip the muscles so freely on the outer side of the iliac crest. In fact, only the region immediately adjacent to the anterior superior spine need be cleared. In this way the important muscles arising from the side of the ilium are left as intact and undisturbed as possible. On a deeper plane the straight and reflected heads of the rectus femoris muscle are divided cleanly by knife dissection, allowing the muscle to be retracted laterally within its sheath, rather than turning it downwards. This is aided materially by dividing the deep fascia over the iliacus muscle as far distally as the motor branch of the femoral nerve. This simple dissection allows a

surprising degree of relaxation in the whole of the operation area. The capsule is excised from the anterior, superior, inferior and (after dislocation of the joint) posterior surface of the femoral head just proximal to the junction of the head and neck of the femur. A clean-cut capsular margin, rather than rough irregular tags, is less likely to cause bony proliferation in the healing stage, and burning with diathermy also helps in this respect. Like the edge of the capsule, the overgrown bone margins of the acetabular rim and femoral head must also be cut cleanly with a sharp osteotome, and later the raw bone margins are touched with the diathermy. Throughout the operation careful sharp dissection is important; rough subperiosteal stripping predisposes to new bone formation later. The accurate reshaping of femoral head and acetabulum are important points. The acetabulum is reshaped and deepened to the inner pelvic cortex, and a good acetabular roof, doming upwards in the axis of the femoral neck, is essential.

FIG. 6

Radiograph of a cup arthroplasty that satisfies all the criteria discussed. A patient who has such a post-operative radiograph seldom has a bad result.

The use of Vitallium as opposed to ordinary stainless steel is believed to be of significance. No harmful reaction between the metal and the bone has been noted.

In the post-operative management, too much emphasis has been placed on physiotherapy rather than on the patient's own activities. After leaving hospital at the end of seven or eight weeks most patients can carry out their own programme of exercises in conjunction with their ordinary household duties. Only if home or social conditions are inadequate should regular attendance at a physical medicine department be advised. On the other hand, all these patients require regular examination by the surgeon, who should correct faults in gait, decide the time for changing from crutches to sticks and finally for walking unaided, and make any necessary adjustments from alteration in limb length. The avoidance of over-fatigue must be stressed, especially in the early stages, and clearly the whole programme must be made elastic and adaptable to the individual patient, who is often elderly. Those in

sedentary occupations can often return to work in three months, and heavier forms of work are graded accordingly. Clearly, a long and costly rehabilitation is not required when such good use can be made of a patient's own activities such as walking, stair-climbing, bicycling, car driving and the use of public transport.

CONCLUSIONS

The conclusion to be drawn from the detailed study of this whole series is that arthroplasty can be worth while, particularly in osteoarthritis. Strong preference is given to the Smith-Petersen technique, which, however, must be followed meticulously. The early after-care is of great importance, but should not involve a long time in hospital. The emphasis, as in all forms of rehabilitation, should be on the patient's own active exercises and graduated use of the joint.

In the five-year survey of mould arthroplasty, the striking radiological features in the successful results include a sound acetabular roof, the absence of surrounding new bone, the establishment of a new joint space and the maintenance of the original relationship of the mould, femoral head and acetabulum.

The analysis suggests that any Smith-Petersen arthroplasty with no early complications and with a radiograph resembling Figure 6 will be followed by an excellent result in the great majority of cases.

We conclude also that in any series of patients operated upon through the lateral approach with trochanteric osteotomy, it is probable that approximately one patient in four will be dissatisfied with the result, no matter what other factors apply.

SUMMARY

1. Two hundred and eleven cases of arthroplasty of the hip have been studied in an attempt to establish the causes of success and failure by comparing the excellent, good and bad results.
2. The findings suggest that the result of an arthroplasty depends largely upon four factors: the surgical approach to the hip joint, the acetabular roof, the interposition substance, and the early post-operative complications.
3. Some important points in the technique of operation and in the post-operative management are described.

We are most grateful to Mr A. G. Apley, Mr B. H. Burns, Mr R. J. Furlong, Mr A. Naylor, Professor G. Perkins, Mr F. A. Simmonds and Mr R. H. Young for help and encouragement in the compilation of this review.

We are much indebted to Mrs E. Hoare and her staff of the Research and Development Department, Aircraft Division, Messrs Vickers Armstrong Ltd., for their help with the statistics and for supplying Figure 7. We are grateful also to Mr W. A. Langmead, Physicist to the Radiotherapy Unit at St Thomas's Hospital.

One of us was awarded a prize by the South-West Metropolitan Regional Hospital Board for work on which this paper is based. Acknowledgment is made to the Board for permission to publish this work.

REFERENCES

GIBSON, A. (1950): Posterior Exposure of the Hip Joint. Journal of Bone and Joint Surgery, **32–B,** 183.

LAW, W. A. (1952): Osteoarthritis of the Hip. London: Butterworth & Co. (Publishers) Ltd.

MCFARLAND, B., and OSBORNE, G. (1954): Approach to the Hip. A Suggested Improvement on Kocher's Method. Journal of Bone and Joint Surgery, **36–B,** 364.

SMITH-PETERSEN, M. N. (1939): Arthroplasty of the Hip. A New Method. Journal of Bone and Joint Surgery, **21,** 269.

SMITH-PETERSEN, M. N. (1948): Evolution of Mould Arthroplasty of the Hip Joint. Journal of Bone and Joint Surgery, **30–B,** 59.

SMITH-PETERSEN, M. N. (1949): Approach to and Exposure of the Hip Joint for Mold Arthroplasty. Journal of Bone and Joint Surgery, **31–A,** 40.

THE DIRECT APPROACH TO CONGENITAL DISLOCATION OF THE HIP*

E. W. SOMERVILLE and J. C. SCOTT, OXFORD, ENGLAND

From the Nuffield Orthopaedic Centre, Oxford

There is an old saying that we plant trees for posterity. Equally in the treatment of congenital dislocation of the hip it is our successors who will judge our results rather than ourselves. Even so, periodic reviews of any new approach to the problem are necessary to assess its apparent value.

In the past six years we have developed a direct approach to the problem of congenital dislocation of the hip based on the belief that there are certain structural abnormalities which must be corrected if the hip is to develop normally (Somerville 1953*b*). These abnormalities we have corrected by operation rather than by leaving the correction to the uncertainty of time and nature alone. It is only by observing the results of such deliberate correction of known abnormalities that their significance in the etiology and prognosis of the condition can really be assessed.

This programme is based upon our interpretation of the mechanics of the dislocation. Emphasis is placed on each stage, and that they should be carried out separately. The purpose of this paper is to describe briefly the reason for each step and how it is carried out, and to comment on the interim progress.

TREATMENT

This paper refers only to " typical " congenital dislocation of the hip in children at the critical age in which they are commonly brought for treatment—that is, from the beginning of walking, or just before, to five years. Some of the procedures described here are also applicable to patients outside these limits, but such cases will not be considered here.

The programme of treatment may be divided into four stages: 1) reduction; 2) establishment of full medial rotation and removal of an intra-acetabular obstruction when this is present; 3) correction of anteversion by means of a rotation osteotomy of the femur; and 4) mobilisation.

Reduction—It is necessary for the femoral head to be reduced into the acetabulum with the least possible trauma. This has been achieved by the use of the double abduction frame (Scott 1953). The method permits gradual reduction with progressive stretching of soft tissue, a process that is usually completed in four weeks.

Establishment of medial rotation, and removal of acetabular obstruction—After the reduction of the femoral head into the acetabulum it is necessary to obtain full medial rotation of the hip, but when the limbus of the acetabulum is inverted sufficiently to cause an obstruction it must first be excised (Somerville 1953*a*). On the other hand, if the limbus is not inverted sufficiently to cause a real obstruction all that is necessary is to place the hip in full medial rotation. This is best done by applying a plaster spica under general anaesthesia with the hip in about 40 degrees of abduction and the greatest degree of medial rotation that can be obtained without force. If this is insufficient it will be necessary to repeat the process after two weeks, when it will be found that the hip will seemingly go into 90 degrees of medial rotation quite easily, and in this position it is immobilised for a further two weeks. We say seemingly 90 degrees of medial rotation because, whereas the leg will be 90 degrees rotated, the hip will be much less rotated on account of the anteversion of the femoral neck; indeed, unless the posterior structures are adequately stretched the hip may not be medially rotated at all.

If the limbus has been excised the leg is immobilised in a hip spica in full medial rotation and extension, and about 40 degrees of abduction. This spica is left on for one month.

* Based on a paper read at a meeting of the British Orthopaedic Association at Gleneagles in May 1956.

Correction of anteversion—The spica is removed and an adequate lateral rotation osteotomy is performed just below the lesser trochanter. The fragments are fixed with a plate and four screws. Experience has shown that the degree of rotation required is 60 to 90 degrees, depending on the anteversion and the amount of medial rotation obtained at the previous stage of the treatment. If the neck of the femur is in a valgus position it is advisable to angle the osteotomy into varus. The fragments unite in six weeks.

Mobilisation—Up to this point treatment has taken about fourteen weeks, and all that remains is to allow the hip to become mobile and for the child to begin walking. When the plaster is first removed spasm, if present, can be avoided by applying skin traction with 1 to 2 lb. weight for a week while the movements of the hip are begun by the child's movements in bed.

When free, the child should be kept by day sitting in a chair rather than lying, and be encouraged to crawl and walk as soon as possible. We have found that progress in mobilisation tends to be more rapid at home than in hospital.

THE RATIONALE OF THIS TREATMENT

THE OBSTRUCTION TO FULL REDUCTION

Extra-articular obstacles—The first obstacle to reduction is the shortened muscles. Certainly these can be stretched by manipulative manoeuvres in which the head is reduced into the acetabulum with the hips flexed, the legs being abducted and extended. This, however carefully done, must cause great pressure on the femoral head, which is probably one of the chief causes of osteochondritis. The soft tissues must be stretched gradually to reduce leverage on the femoral head to a minimum. Most of the stretching must be done before the head enters the acetabulum. Gradual reduction on a frame fulfils these criteria admirably. Experience has shown that it is wise, once the head is opposite the acetabulum, to allow several days to elapse before proceeding. This ensures that the stretching is complete. It is wise to treat subluxation, even a minor one, in this way as well as complete dislocation.

Intra-articular obstruction—At this point in treatment the hips must be differentiated into two types: those in which there is in the acetabulum no mechanical obstruction to reduction, and those in which an obstruction is present. In this paper we refer to these two types (which are only stages in the same condition) as subluxation and dislocation. It is not always possible to differentiate between these types without the aid of arthrography.

ARTHROGRAPHY

It is wise to undertake arthrography after the initial frame reduction. In the earlier cases we also obtained arthrographs before treatment was begun, but we have now discontinued this in order to reduce the number of anaesthetics.

Arthrography is carried out under general anaesthesia, and the skin receives the usual pre-operative preparation. A 17 per cent solution of diodone is injected into the hip joint by the anterior route until the joint is full but not tense. If the 35 per cent solution (as supplied in ampoules) is used it will be found to be too dense and may obscure the soft-tissue outlines. If too little fluid is injected the joint may be inadequately filled, with consequent fallacious appearance. On the other hand, if the tension is too great, the head may be " blown " out of the joint, with exaggeration of the displacement. In a child of eighteen months about 4 millilitres of fluid is sufficient.

It is not easy to direct the needle into the joint, which, being empty, is only a potential space. The needle is pushed into the femoral head just below the inguinal ligament and lateral to the femoral artery. The leg is moved to make sure that the needle is in the femoral head. While gentle pressure is applied to the plunger of the syringe, the needle is gently withdrawn until the fluid runs in freely. When the pressure on the plunger is released the fluid should run back into the syringe; this is the only sure indication that the fluid is in the joint. If arthrography is done before reduction of the dislocation it may be made easier by applying

traction to the leg, thus relaxing the capsule. The radiographs must be taken without delay, otherwise the sharp outlines will be lost by absorption of the fluid.

In all arthrographs there are many shadows to be seen, and there is consequently a tendency to read too much into them. There are two principal features to be looked for:

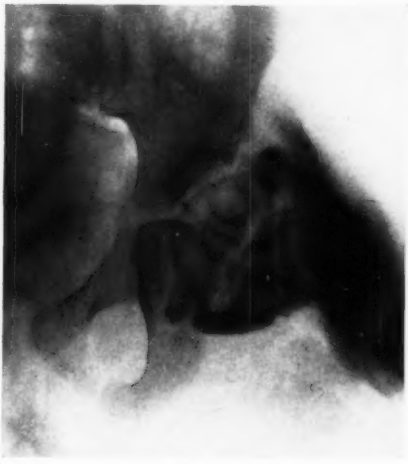


FIG. 1

FIG. 2

Figure 1—Arthrograph of a normal hip showing the head fitting accurately in the acetabulum without pooling. The limbus can be clearly seen. Figure 2—Arthrograph showing a subluxation. The extent to which the acetabular roof is cartilaginous is well demonstrated. The femoral head does not fit well into the joint, and the limbus is somewhat pressed up.

FIG. 3

FIG. 4

Figure 3—Arthrograph of a dislocated hip. This makes an interesting comparison with Figures 1 and 2. The limbus is grossly deformed and turned into the joint. Figure 4—Arthrograph after the head of the femur has been pulled down to the acetabulum. The limbus is forming an obstruction which prevents the femoral head from sinking into the acetabulum, and it permits pooling of the fluid.

the position and shape of the limbus; and pooling of the contrast medium in the floor of the acetabulum.

The limbus in a normal hip (Fig. 1) is easily distinguishable. It fits closely to the femoral head and tapers to a sharp point with a notch distal to it. In a subluxation the limbus and

roof of the acetabulum are displaced upwards so that the roof becomes elongated upwards and apparently deficient, but otherwise the general conformation remains unchanged (Fig. 2).

In a dislocation the appearance is totally different (Fig. 3). The limbus is seen as a globular tag turned into the cavity of the acetabulum. The lower part of the capsule is drawn up, which gives the appearance of an hour-glass constriction. The apparent constriction is

FIG. 5
A typical limbus after excision (scale in centimetres and inches).

due to the redundant capsule's being drawn up by the displaced anteverted femoral neck to which it normally clings closely. The capsule forms no obstruction to reduction except when it becomes adherent, as it may in older children.

After the head has been reduced into the acetabulum the limbus is seen to be compressed against the cartilaginous roof. Its size, shape and significance under these circumstances have been described elsewhere (Somerville 1953*a*).

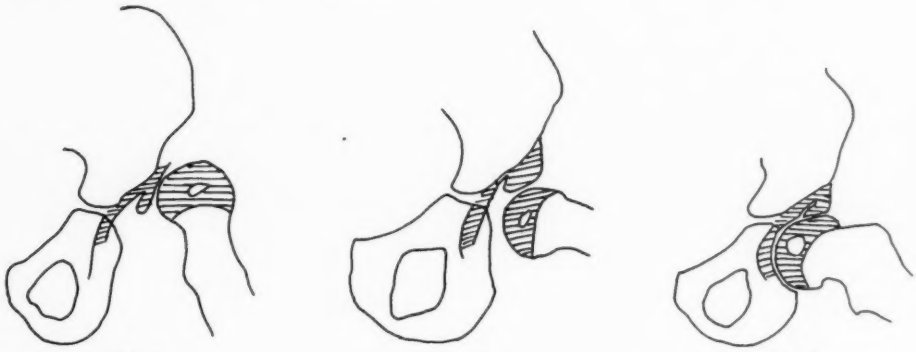


FIG. 6 FIG. 7 FIG. 8

Figure 6—Diagrammatic representation of a dislocation showing the inverted limbus. Figure 7—The head has been pulled down and the limbus is turned into the joint. Figure 8—With time the femoral head has sunk into the floor of the acetabulum by compressing the limbus into the acetabular roof, and to some extent it has itself become flattened.

Pooling of the contrast medium in the lower part of the acetabulum is evidence that the femoral head does not fit accurately into the acetabulum (Fig. 4). This is quite different in subluxations and dislocations (Figs. 2 and 3) and no pooling is seen in the normal hip (Fig. 1).

If the arthrograph shows that an obstruction is present we have, in almost all instances, proceeded to remove it under the same anaesthetic. The evidence at present available suggests

that it is usually advantageous to remove the inverted limbus, but the question undoubtedly arises: does every inverted limbus need to be removed? The answer is probably no. The problem is to determine which must be removed, and which may safely be left. Our policy has been that if the inverted limbus is small, or if it does not prevent easy complete reduction without delay so that no pooling is seen in the arthrograph, we have left it in position; but

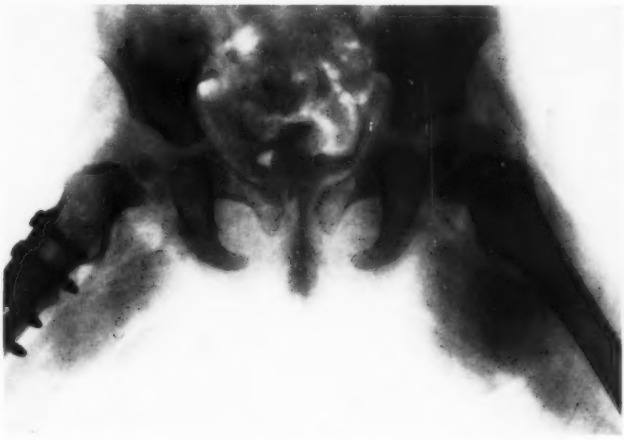


FIG. 9
Case 1—Hip after treatment at the time mobilisation was started. A rotation osteotomy of 60 degrees had been performed.

FIG. 10

FIG. 11
Case 1. Figure 10—Six weeks later the hip has dislocated: derotation had been inadequate. Figure 11—A further rotation osteotomy of 40 degrees was done, and three years later the hip is stable.

in all other cases except three the limbus has been excised. These three were cases of bilateral dislocation in which a sizable limbus was deliberately left in one hip but removed from the other so that progress could be compared.

The inverted limbus is a substantial fibrocartilaginous structure (Fig. 5) which will stand up to the pressure of the head and, unless it is soft, as in a very young child, it has little chance

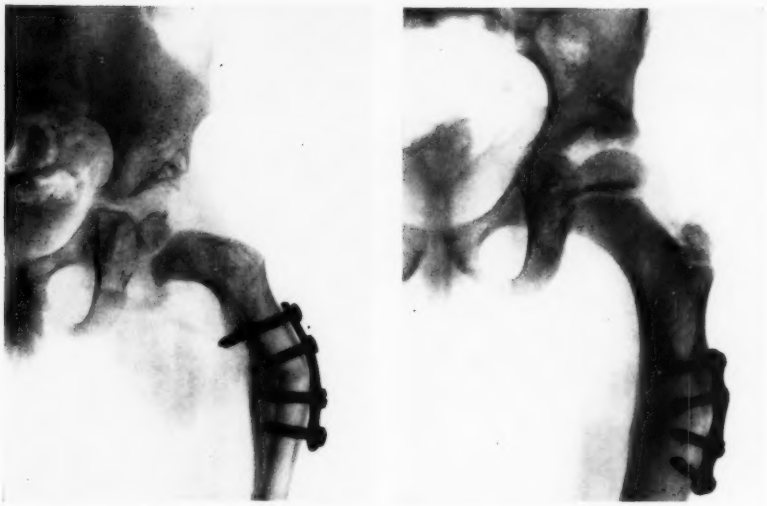


FIG. 12 FIG. 13

Case 2. Figure 12—After a rotation-adduction osteotomy. Figure 13—Three years later. The neck is much more valgus.

FIG. 14 FIG. 15

Case 3. Figure 14—An adduction osteotomy was done some years previously. Although the plate is on the lateral aspect of the femur, with the leg in the functional position, it lies posteriorly because the anteversion was uncorrected. Figure 15—The same plate was reapplied after a 70 degrees' rotation osteotomy.

of being pressed out of the way. Instead it becomes pressed into the soft cartilaginous roof of the acetabulum where it forms a deep groove, producing a deficient acetabulum, and an irregularity of the head (Figs. 6 to 8).

Furthermore the inverted limbus reduces the size of the acetabulum so that any attempt to force a reduction may cause considerable compression of the femoral head. If the pressure is prolonged it may cause flattening and malformation of the femoral head, and may well be a factor in the development of osteochondritis.

ROTATION OSTEOTOMY

Persistent anteversion necessitates prolonged immobilisation and is the commonest cause of recurrent subluxation. This late redisplacement may be a gradual, insidious process, and by the time action is taken it is often too late to produce a satisfactory result. It is scarcely fair to assess the results of rotation osteotomy in such circumstances, when it has been used as no more than a last desperate salvage operation. How much better to have prevented the recurrence from ever taking place.

To ensure a stable reduction and to allow early mobilisation it is our practice to perform a rotation osteotomy as early in the course of treatment as is practicable in all cases, whether of subluxation or dislocation, and whether or not the limbus has been excised. We base this policy on the evidence that stable reduction is obtained with the hip fully rotated medially, and it seems logical to leave the hip in this stable position but to turn the leg to the front by means of an osteotomy. We have found that it is best to do the osteotomy immediately below the lesser trochanter, and that the fragments must be fixed with a plate and four screws to prevent loss of position (Somerville 1957).

Experience has also shown that the degree of rotation must be from 60 to 90 degrees depending on the amount of anteversion and degree of medial rotation obtained beforehand. Attempts to do less have led to failure which has been corrected by a further rotation osteotomy (Figs. 9 to 11). Excessive valgus of the femoral neck should be corrected at the same time by bending the four-hole plate, provided osteotomy is as high as possible (Fig. 12). The varus tends to become corrected spontaneously as growth proceeds (Fig. 13).

Some surgeons believe that the valgus deformity of the femoral neck alone need be corrected, but despite the improvement afforded by adduction osteotomy it leaves much to be desired. In one child—not in this series, but from an older group—an adduction osteotomy alone was done (Fig. 14). Some degree of subluxation persisted. The osteotomy was revised and, while the varus was maintained, the lower fragment was rotated 70 degrees. The original plate was reapplied without altering the degree of angulation (Fig. 15).

MOBILISATION

Six weeks after the osteotomy the plaster is removed and mobilisation is started. Our aim up to this point has been to correct the mechanics of the joint. The rapidity of recovery of movement and normal joint development is a measure of our success. The period of mobilisation varies considerably. Full movement is usually regained within six months, and in no case has the child regained less than 90 degrees of flexion within this period. Occasionally it will be found that after removal of the plaster the hip is at first a little irritable, and becomes flexed and rotated laterally. Any attempt at movement is resented, and a radiograph suggests that the hip is subluxating. In such circumstances we apply skin traction with a 1-lb. weight hanging over the end of the bed for seven to ten days, by which time the hip will have settled and mobilisation may be resumed safely.

In some cases it will be found that although there is no spasm the hip tends to lie in lateral rotation during mobilisation, and the radiograph suggests that the head is standing out. Provided there is no obstruction, and an adequate rotation osteotomy has been carried out, the best policy is to get the child up and walking, or, if this is not immediately possible,

crawling or sitting in a chair. It is unwise to delay weight bearing by putting the child to bed, and the best course is to send the child home with instructions to this effect, so that the temptation to treat the hip will not arise. Children regain movement better at home. The reason for encouraging weight bearing in such circumstances is that in the upright position the child will always turn the foot to the front, forcing the head of the femur backwards into the acetabulum. If the child lies supine in bed, or even sits in bed, the leg lies in lateral rotation and the condition is aggravated.

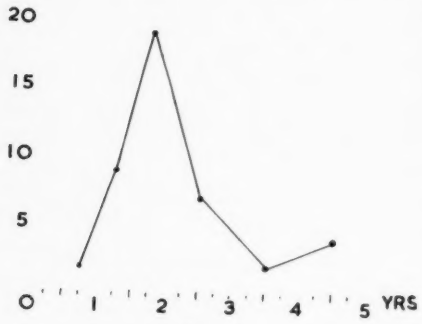


FIG. 16
Graph showing ages at the time of diagnosis.

Once the child is walking no restrictions are placed on the activities. We believe that once the mechanics of the joint have been corrected, the more normally the hip is used the more likely it is to develop normally, and that any form of restraint, particularly in some unnatural or bizarre position, should be unnecessary.

PROGRESS

This paper is based on a study of fifty dislocated hips in forty-four patients—treated consecutively. There were forty-two girls and two boys. In twenty-eight patients the left hip was affected, in ten the right, and in six both. In four patients with dislocation on one side a subluxation was present in the other hip. The longest period of follow-up is seven and a half years, and the shortest three years. The age at diagnosis is shown in Figure 16. It will be seen that most dislocations were diagnosed between the ages of one and a half to two years, and only two below the age of one year (both at nine months).

Few complications have arisen. In two cases there was some superficial sepsis which in no way interfered with the course of treatment. Five children sustained a fracture of the femur during the period of mobilisation, or during the subsequent year.

FIG. 17

FIG. 18

Case 4. Figure 17—Initial radiograph showing dislocated hip. Figure 18—Eight months later. The hip was clinically normal.

FIG. 19

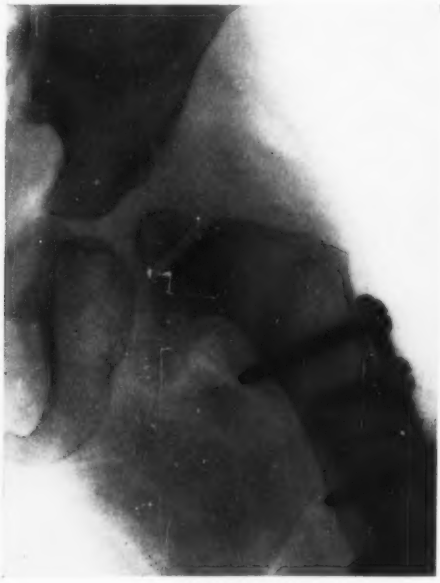


FIG. 20

Case 5. Figure 19—Dislocated hip in a child aged two years three months. Figure 20—Four and a half months later, when mobilisation was begun.

FIG. 21

FIG. 22

Case 5. Figure 21—Ten months later still. There is clinically normal function, but ossification of the ilium is still defective. Figure 22—After a further year the ossification of the acetabulum is much improved.

In four cases the hips presented some problem after mobilisation had begun, but in three of these this was the result of a deliberate variation in technique.

In the remaining forty-six hips the course of treatment has been uneventful, with results which are clinically normal. Radiologically the results are less good when considered in detail, but a characteristic feature has been the progressive improvement which has taken place with growth. This is not a feature of hips which have been treated by the more conventional methods.

It seems to us that in estimating the results of treatment it is best to consider the development of each individual component of the joint.

The acetabulum—We were aware of the possibility that excision of the limbus might interfere with the development of the acetabulum. This has not proved to be the case; indeed the removal of the inverted limbus seems to assist acetabular development, though this does not mean that all hips will subsequently develop a normal acetabulum. Figure 17 shows the dislocated hip of a child in which the ossification of the acetabulum is defective. The limbus was excised, and eight months later the radiographs showed that rapid development had taken place in the ossification (Fig. 18). By the time some hips come to treatment ossification may be retarded to such an extent that full recovery is not possible.

Figure 19 shows the hip of a child of two in whom ossification of the acetabulum was very deficient. The limbus was excised and mobilisation was begun three months later. At that time radiographs showed a bony acetabular roof seemingly insufficient to prevent the femoral head from riding up (Fig. 20). Despite this, the child was encouraged to walk and use the limb normally as soon as possible without restraint. Radiographs after a further year showed an appearance of deficiency (Fig. 21) although the hip was clinically normal, but two years later still the radiological appearance was much improved (Fig. 22).

On the other hand, if the limbus remains in the inverted position it may be pressed into the acetabular roof, with consequent delay in the ossification and development of this region. Figures 6 to 8 show this diagrammatically, and Figures 23 to 25 show how deceptive an arthrograph may be after this has happened. In this instance, after a well shaped acetabulum had developed, as seen radiologically, the hip remained unstable. The hip was explored and a large limbus was excised; since then the hip has developed well.

The femoral head—The development of the femoral head is one of the main factors affecting the results of treatment of congenital dislocation of the hip. One big problem in all accepted methods of manipulative reduction has been the development of osteochondritis, presumably from interference with the blood supply to the ossific nucleus. The cause for this has been variously ascribed to injury at the time of reduction, to compression of the vessels supplying the head by twisting the capsule, and to extensive pressure on the head after reduction, from tightness of the shortened muscles.

In our series we have not encountered a hip in which the radiological changes associated with osteochondritis have appeared, and the development of the ossific nucleus of the femoral head has, on the whole, been good.

The factors mentioned above as being responsible for osteochondritis have been eliminated, so far as possible, by the use of the frame (Scott 1953). It may be that there is another causative factor that has been eliminated in this programme of treatment. The inverted limbus reduces the size of the acetabulum, and the femoral head, which is normal in size, is forced into the acetabulum. The consequent pressure may be sufficient to interfere with the circulation to the ossific nucleus. Excision of the limbus, by increasing the size of the acetabulum, may prevent this pressure from interfering with the circulation to the head.

With the recovery of function, and when the mechanics are normal, the ossific nucleus grows rapidly. Usually the outline becomes a little shaggy and irregular. This appearance is due to rapid growth, which suggests that there is no vascular insufficiency.

A second nucleus often develops in the medial part of the head, giving the whole ossific

nucleus a somewhat elongated appearance (Figs. 26 and 27). The two nuclei soon fuse (Fig. 28) and the whole progressively increases in size. In some hips the primary centre placed laterally

FIG. 23
Case 6—Plain radiograph of the hip after reduction before arthrography.

FIG. 24 FIG. 25
Case 6. Figure 24—Arthrograph after the " reduced " position had been maintained for three months, showing the well shaped acetabulum, but instability because the head stands out. Figure 25—Condition four years after the limbus was excised.

in the head grows more rapidly than the medial centre, producing a progressively increasing valgus.

FIG. 26

FIG. 27

FIG. 28

Case 7. Figure 26—Hip at completion of treatment and about to begin mobilisation. Only one ossific centre is visible and it is round. Figure 27—A second ossific nucleus is visible medial to the original one. Figure 28—Two years later. The two centres are fusing.

It seems likely from these observations that the normal femoral head is formed from two ossific nuclei which, when they develop simultaneously, are not usually seen as separate entities, but in congenital dislocation the development of the medial centre is delayed, or perhaps suppressed altogether, unless a stable reduction is obtained early. It is interesting to

FIG. 29

A case of Perthes' disease. The lateral part of the head is defective, but the medial part is normal.

compare this with Perthes' disease in which the lateral centre degenerates, whereas the medial one is often preserved (Fig. 29).

The upper end of the femur—This method of treatment produces well defined Harris's lines which show clearly the way in which growth takes place in the upper end of the femur

FIG. 30

FIG. 31

Case 8. Figure 30—Radiograph a year and a half after completion of treatment, showing a varus and short femoral neck. Figure 31—Four years later, showing well shaped head and neck.

FIG. 32

FIG. 33

Case 9. Figure 32—In this exceptional case it was necessary to combine an exaggerated degree of adduction with the rotation at the osteotomy. Figure 33—Only eighteen months later the coxa vara is much less and the hip remains stable.

(Somerville 1953*b*). There is a continuous metaphysis from the medial side of the head to the outer side of the greater trochanter (Trueta 1957), and in the early stages at any rate it seems from measurements that equal growth takes place at the two ends of the femur; but when two separate epiphysial nuclei develop the rate of growth at the upper end is reduced. With this arrangement of two epiphyses any inequality of growth between them will result in alterations of the anteversion or of the valgus or varus angle, and that these two angles can progressively alter to the detriment of the joint is undoubted. There has been a tendency in all the hips treated for the neck to become progressively more valgus.

When the hip was varus to begin with this tendency does not matter (Figs. 30 and 31), but when the neck-shaft angle is at first normal, or even a little valgus, further valgus may cause impairment of development. As already mentioned we have not hesitated to produce varus at the site of osteotomy when necessary, even to the extent of creating considerable deformity, which will either become corrected spontaneously or can be corrected at a later date, if necessary, after the joint has developed (Figs. 32 and 33).

In the same way, if the angle of anteversion has been inadequately corrected, or if the hip remains unstable, the anteversion will recur. A child aged two years was treated for a congenital dislocation with manipulation and immobilisation in the " frog " position for one year. Some time after she had been free it was found that the hip was subluxating, and that anteversion was excessive. A rotation osteotomy of 90 degrees was carried out. The hip was still unsatisfactory, and three years later a further lateral rotation osteotomy of 90 degrees was carried out. At the age of eighteen years the hip, which was dislocated, was causing pain, and a Charnley central dislocation stabilisation was carried out. In order to do this it was found necessary to perform a lateral rotation osteotomy of 90 degrees. Thus this girl's femur had been rotated by osteotomies through 270 degrees in one direction, and finally lay in the neutral position.

In our series it is not uncommon to find that after rotation osteotomy there is some excessive lateral rotation for a while, but that this progressively diminishes and medial rotation correspondingly increases. It is, therefore, wise to produce more lateral rotation than might seem to be necessary on purely theoretical considerations, and we have never regretted doing so.

DISCUSSION

It is impossible to compare the results of one series of treated congenital dislocations of the hip with another because of the remarkable variation in results recorded in the literature, even though the methods used may have been similar. Many authors have commented on this feature, and Hass summarised it well thus: " In a collective German review begun by Deutschlander and continued by Reiner, including thousands of cases, the percentage of cures reported by various surgeons in unilateral dislocations varies from 8 per cent to 78 per cent, and in bilateral dislocations from nil to 75 per cent." This speaks for itself, but there must be some reason other than over-optimism or over-pessimism to account for such remarkable variations. Among these reasons are, firstly, the fact that functional results are so very much better than anatomical ones and therefore very misleading, and in some instances the functional result has been either taken as the criterion of success or has been taken too much into account in assessing the result. In actual fact the functional result in the early stages is of little significance, and in assessing the benefit of treatment it is better to judge from the anatomical result. In our series, apart from minor degrees of limitation in range of movement outside the normal functional range to be found in a few children, there are three children who limp—one because she subsequently developed poliomyelitis and has paralysis below the knee, the hip being stable and developing well; a second child with bilateral dislocation, first seen at the age of four and a half years, who, although the Trendelenburg test is negative, has a dip when walking; and the child whose hips are illustrated in Figures 32 and 33, who in spite of the radiological appearance has only a slight dip when walking, and this is

improving steadily. In this case the varus was produced deliberately to keep the head in the acetabulum, and once the hip has developed, if it has not been corrected spontaneously, it may be corrected by operation.

The second cause for the discrepancy is that the age of the patients is not always taken sufficiently into account. Clearly, a series in which the age at diagnosis is low is likely to show much better results than a series in which it is high. The average age at diagnosis is worthless in estimating this.

Thirdly, in many instances, the stage at which the dislocations were encountered—that is, whether it is a subluxation or a full dislocation with inverted limbus, is with few exceptions ensured. It is, in fact, often impossible to differentiate between these two important stages without the use of arthrography. In our series we have confined ourselves to fifty consecutive hips in which dislocation was complete, and that the limbus was turned into the joint was

FIG. 34

FIG. 35

Figure 34—A case of proved synovial tuberculosis. Figure 35—The same hip six years later. Function is normal, but there is an obvious subluxation due to overgrowth of the head and a valgus neck.

proved, first by arthrography and then by exploration. We have only mentioned subluxation for comparison in diagnosis and treatment. Since subluxation is an earlier stage in the condition its treatment is easier, though the final result is still largely dependent on the degree of damage that has been done, and the capacity of the tissues to reconstitute themselves when the mechanics of the joint have been corrected.

A feature of almost every published series is that the effectiveness of treatment is estimated solely on the percentage of good results obtained, such as " 25 per cent normal or near normal, 15 per cent functionally satisfactory for a while, and 60 per cent failures," which are the figures quoted for one series. When we consider that we are treating a condition which, if left untreated, will not result in pain for very many years, even if it does produce lameness, a failure becomes a tragedy, and a method of treatment which reduces such misfortunes, or, better still, eliminates them altogether might well have more to be said for it than one with

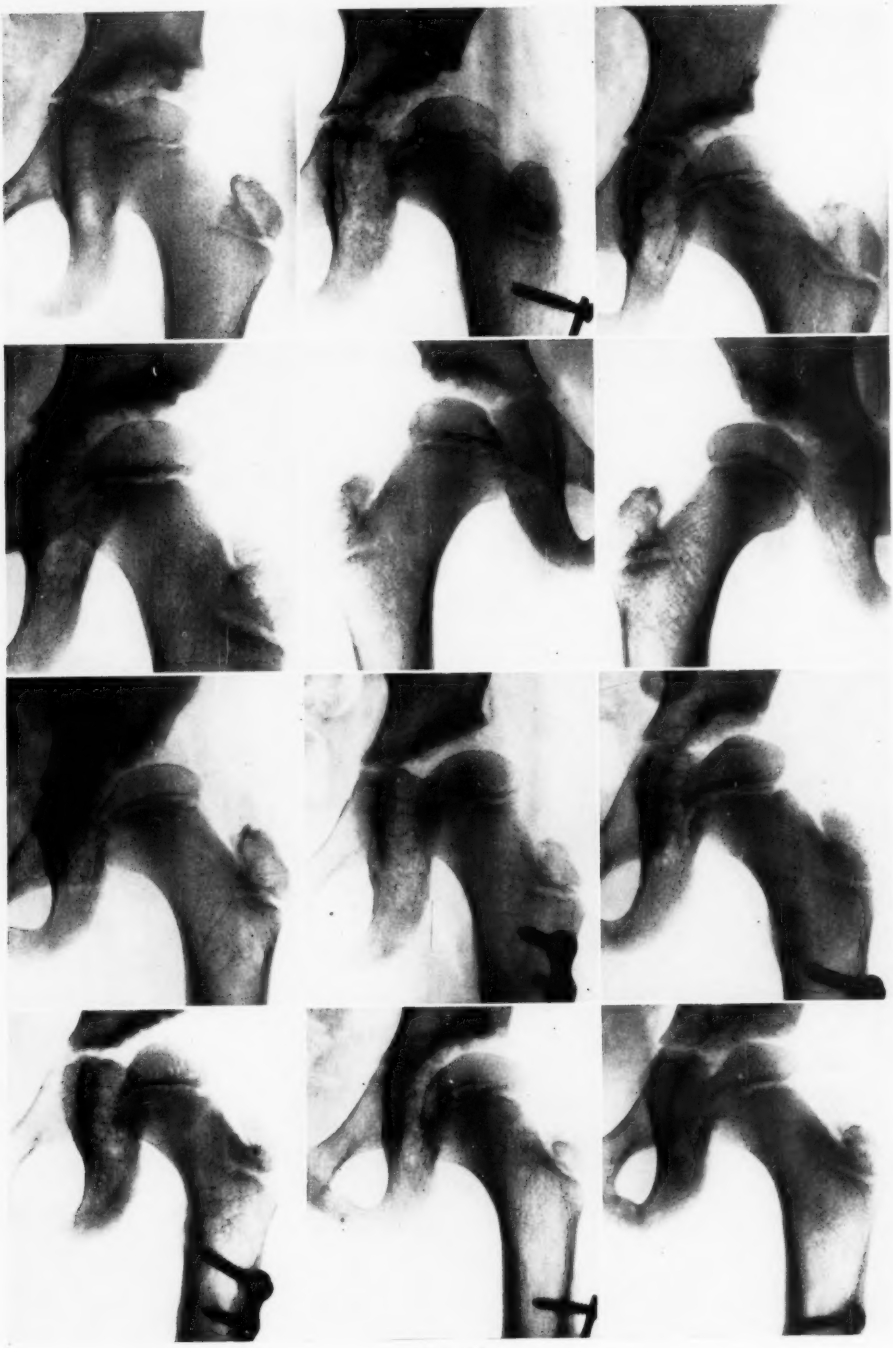


FIG. 36

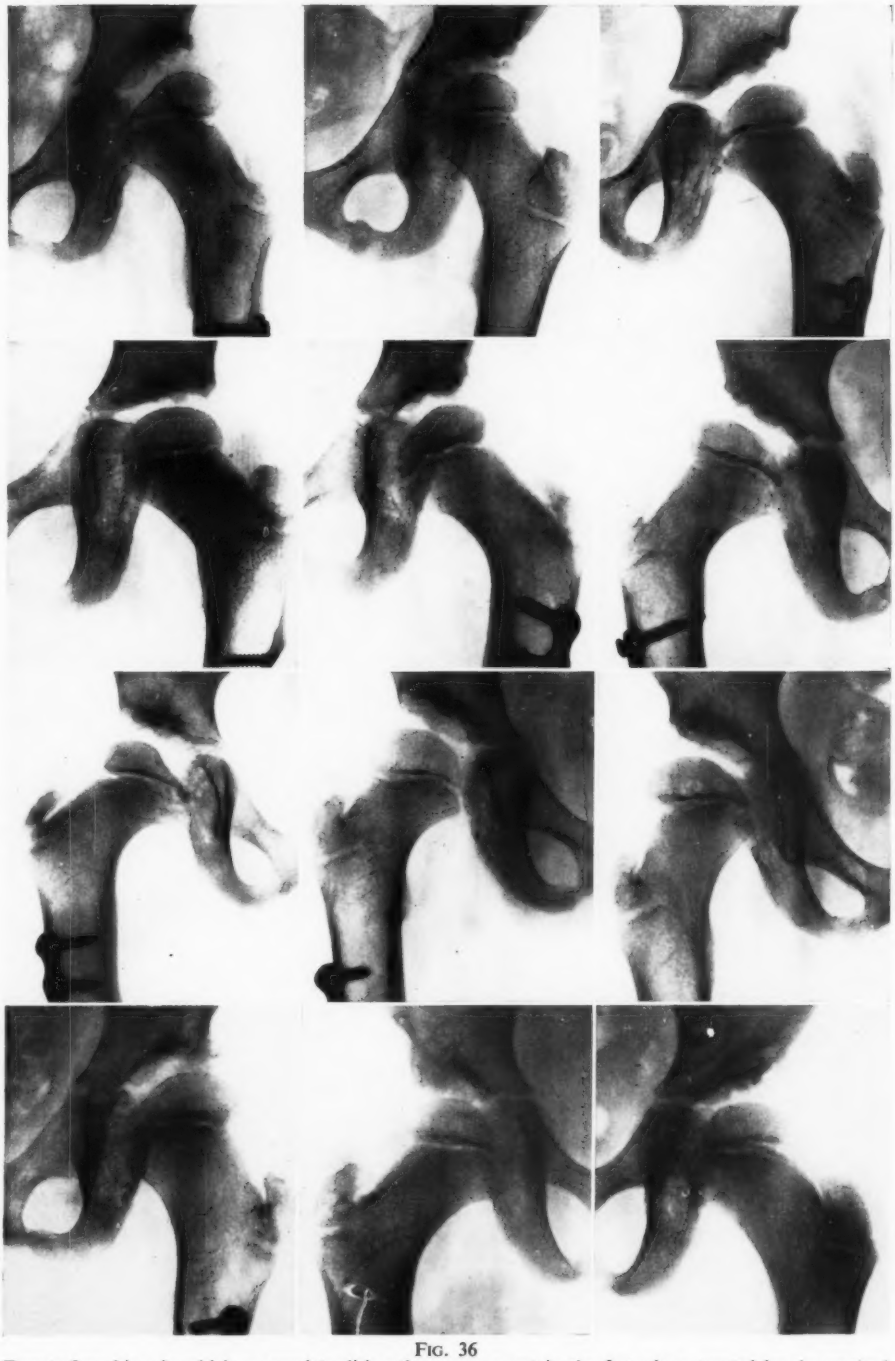


FIG. 36

Twenty-four hips, in which a complete dislocation was present in the first place, treated by the method described. The illustrations are in chronological order, and the follow-up time varies from seven and a half years to four and a half years.

a slightly higher percentage of good results but a higher percentage of failures. In our series we have no child, other than the three mentioned (one because of poliomyelitis), who limps. This does not mean that we consider all the hips to be satisfactory. There are eleven hips in which we consider some degree of anatomical instability to be present, either from overgrowth of the femoral head or from increasing valgus of the neck. This overgrowth of the head and valgus of the neck is by no means confined to this method of treatment; in fact it seems to occur almost less commonly with this method. The cause is presumably hyperaemia of the capital epiphysis resulting from stimulation of the head in consequence of its being in the acetabulum, and subjected to normal stress for the first time after being inactive so long. It is not confined to congenital dislocation but may occur, for example, in synovial tuberculosis (Figs. 34 and 35).

Rather than divide the results into good and bad according to our own judgment, we produce the interim results of the first twenty-four hips treated, which are representative of the whole series (Fig. 36). The follow-up is between seven and a half and four and a half years.

A feature of most methods of treatment is the length of time for which the hip must be protected after reduction for it to become stable. We have based our method of treatment on the concept that the mechanics of the joint can be so altered that full normal movement and use of the hip can be allowed at an early date without any form of restraint. The time taken so to adjust the mechanics of the hip is about fourteen weeks, though it could sometimes be reduced to a little less than this. In some of our early cases this time was exceeded because of our uncertainty as to what would happen, and in some other cases delay has occurred from unforeseen circumstances such as the development of colds and other infectious diseases.

The short period of treatment is clearly a tremendous advantage to the child, and relieves the parents from the burden of looking after the child in splints or plaster for a year or more, with the ever present uncertainty that operation may still be necessary. Most parents consider that two comparatively small operations are a small price to pay as an alternative.

CONCLUSIONS

1. A method of treatment of the congenitally dislocated hip is described.
2. The rationale of the treatment is considered.
3. The subsequent development of the hip generally, and of its individual components, is described.
4. Comparison between the results of other methods of treatment and of this method is not attempted for reasons stated.
5. The advantages of a shortened period of splintage are discussed.
6. The state of fifty completely dislocated hips treated consecutively is described at the end of a follow-up period of from three to seven and a half years.

We wish to thank our colleagues who by sending us their patients have helped in the carrying out of this work.

REFERENCES

HASS, J. (1951): Congenital Dislocation of the Hip. Springfield, Illinois: Charles C. Thomas.

SCOTT, J. C. (1953): Frame Reduction in Congenital Dislocation of the Hip. Journal of Bone and Joint Surgery, **35–B,** 372.

SOMERVILLE, E. W. (1953*a*): Open Reduction in Congenital Dislocation of the Hip. Journal of Bone and Joint Surgery, **35–B,** 363.

SOMERVILLE, E. W. (1953*b*): Development of Congenital Dislocation of the Hip. Journal of Bone and Joint Surgery, **35–B,** 568.

SOMERVILLE, E. W. (1957); Persistent Foetal Alignment of the Hip. Journal of Bone and Joint Surgery, **39–B,** 106.

TRUETA, J. (1957): The Normal Vascular Anatomy of the Human Femoral Head during Growth. Journal of Bone and Joint Surgery, **39–B,** 358.

SLIPPED UPPER FEMORAL EPIPHYSIS

Characteristics of a Hundred Cases

H. JACKSON BURROWS, LONDON, ENGLAND

From the Institute of Orthopaedics, Royal National Orthopaedic Hospital, London and Stanmore

When the British Orthopaedic Association commissioned an investigation of the results of treatment of slipped upper femoral epiphysis, it seemed that this might be based more broadly than upon the results of a particular operation popular at the moment, and that the inevitable delay while patients remained under observation would provide an opportunity of studying the clinical characteristics of the disease, and subsequently relating them to the treatment and its results. Possibly a sound etiological classification might emerge, relating the clinical study of the disease to the notable laboratory results of Harris (1950).

To this end a detailed questionnaire was sent out, and the replies were coded on punch cards.

Against the obvious advantages of this method must be placed two disadvantages in particular. First, although every question on the forms is relevant, their completion is tedious, so that some questions go unanswered, and this seriously affects the statistical validity of the information collected from them; indeed some returns cannot be used at all, and so the cases are not consecutive. The other most important disadvantage is that the bother of returning a comprehensive form dissuades many from collaborating, or of collaborating for long, and so diminishes the number of cases for investigation. Everyone, except those who live by them, is tired of forms.

A hundred straightforward cases have been reviewed. A few oddities that have been excluded are mentioned at the end.

SEX, AGE AND SIDE AFFECTED

Sex—The hundred patients comprise sixty boys and forty girls, but there may have been some selection because the cases could not be consecutive. Data have been tabulated for each sex separately, but are here reproduced collectively except when the figures differ much in the two sexes.

TABLE I

SIDES AFFECTED IN EACH SEX

Side	Boys	Girls	Both sexes
Right only	15	14	29
Left only	34	14	48
Right and left	11	12	23
	60	40	100

Age—The age, in years, is at the time of first attendance. As in previous series, there is a striking difference in age between the boys, mostly fourteen to sixteen years old, and the girls,

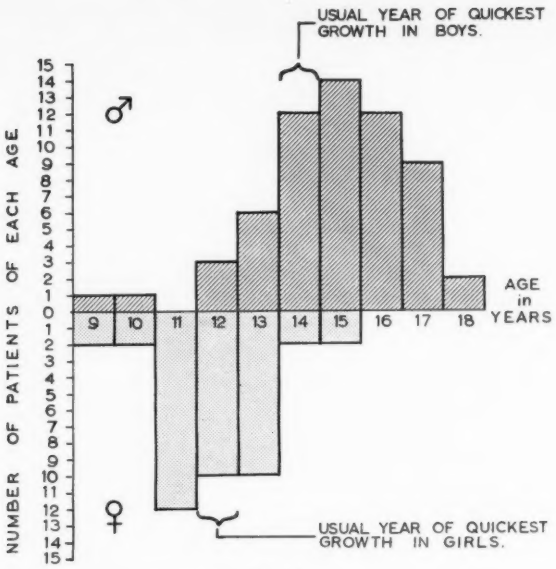

USUAL YEAR OF QUICKEST GROWTH IN BOYS.
NUMBER OF PATIENTS OF EACH AGE
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
♂
♀
9 10 11 12 13 14 15 16 17 18
AGE in YEARS
USUAL YEAR OF QUICKEST GROWTH IN GIRLS.

FIG. 1
The number of patients of each age at the time of first attendance—boys above the base line, girls below.

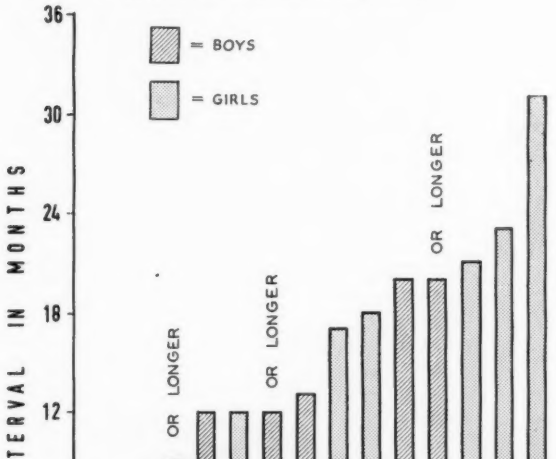


FIG. 2
The interval in months between slipping on the first side and slipping on the other side in fourteen of the twenty-three bilateral cases. Those indicated by the letter N showed no overweight or evidence of endocrine disturbance. The others did (including one case in which gradual slipping appeared to take place synchronously on the two sides).

mostly eleven to thirteen. In other words, the girl is stricken at her preparatory or primary school and the boy at his public or secondary school. The median age in the girls is twelve, their usual year of most rapid growth; the median age in the boys is fifteen, about a year later than their usual year of most rapid growth (Fig. 1).

Side—In boys only the left side was more than twice as often affected as the right (Table I). Both hips were affected in eleven boys and twelve girls.

In one boy aged fourteen years and ten months, abnormally fat, gradual slipping seemed to begin in both hips synchronously, but in all the other patients there appeared to be an interval between slipping on one side and slipping on the other, varying from six months to two years or, in one case, as long as thirty-one months (Fig. 2). Consequently, unless a series of cases is followed for long enough, some that will ultimately become bilateral are recorded as unilateral. Eleven of these twenty-three cases were recorded as one-sided until Mr John Hall's follow-up revealed that the second side had subsequently suffered.

Affection of both hips suggests a constitutional cause, which might have the effect of weakening the bonds of the epiphysis or increasing its burden. Attempts to correlate bilaterality with weight and endocrine function are recorded later.

EVIDENCE OF NUTRITIONAL AND ENDOCRINE FACTORS

Diet—The ascorbic acid excretion test was carried out in six patients. It was normal or nearly so (not more than 50 milligrams required for saturation) in four. It was decidedly low in one patient without evident dietetic fads. It was very low in one patient who, although taking a scorbutic diet without any vegetables at all, showed no clinical evidence of scurvy. Otherwise dietetic fads have been rare, but overfeeding was possible.

Physique—It was remarkable how many hospitals accepting children for prolonged treatment failed to record heights and weights of their charges. Nevertheless the height was recorded in sixty-three children and the weight in sixty.

To make any collective use of these data it is necessary to relate each child's height or weight to that of a normal child of the same age and sex by allotting an index of height (H.I.) or index of weight (W.I.).

Sutcliffe and Canham (1950) prepared tables of height and weight based on measurements made in 1948 of about 17,000 representative boys and girls from scattered areas of rural and urban England. From these tables they prepared indices by which the height (or weight) of a particular child can be compared with that of other children of the same sex and age; that is to say where he (or she) would come among a hundred such children arranged in order of height or weight, if indeed he came within their range at all.

Height—Figure 3 shows the result of preparing such indices of height for the thirty-five boys and twenty-seven girls whose height was recorded. The indices are plotted horizontally, and the number of children in each range is plotted vertically. The heavy outline shows the distribution expected in the same number of normal children: 10 per cent expected to have indices between 65 and 81; 15 per cent between 81 and 90; 50 per cent between 90 and 110; 15 per cent between 110 and 119; and 10 per cent between 119 and 135. Most of the sixty-two patients come within the expected range of height for sixty-two normal children of their age, but fewer patients are smaller than the average for their age and more are taller, though still within the normal range for their age. In other words, fewer are unusually short and more are unusually tall. Three girls have height indices above any in the normal range, and these patients can appropriately be described as not merely *unusually* tall, but *abnormally* tall. Figure 4 shows the figures for boys and girls more clearly differentiated, boys above the base line and girls below it.

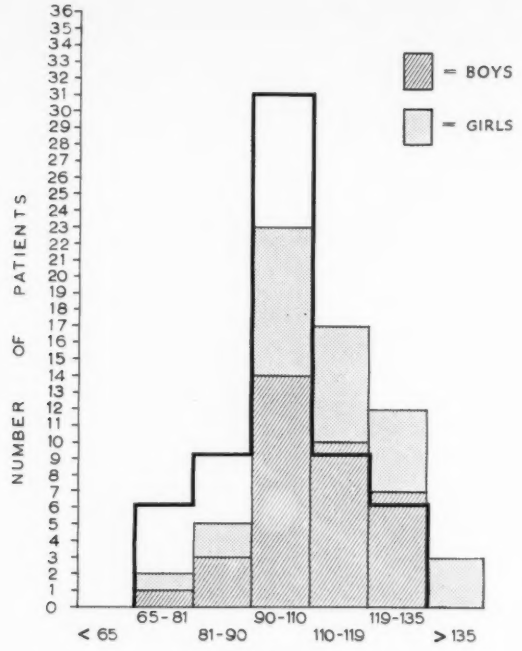


FIG. 3

The index of height for the sixty-two patients whose height at the outset was recorded. The expected indices for an average sample would be enclosed by the heavy outline.

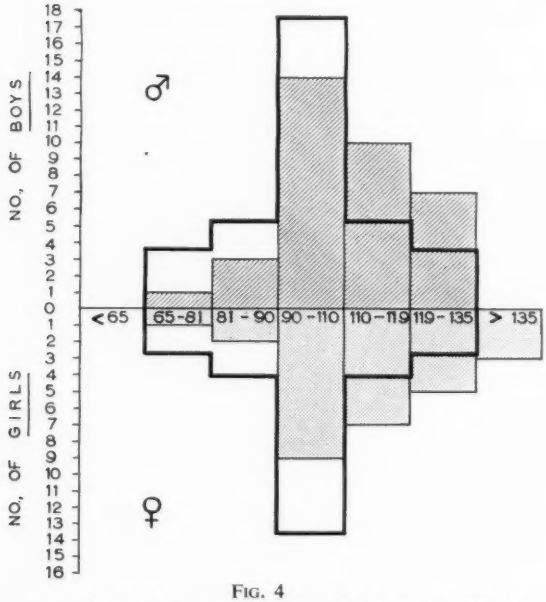


FIG. 4

As Figure 3, but with the data for boys plotted above the base line and for girls below it.

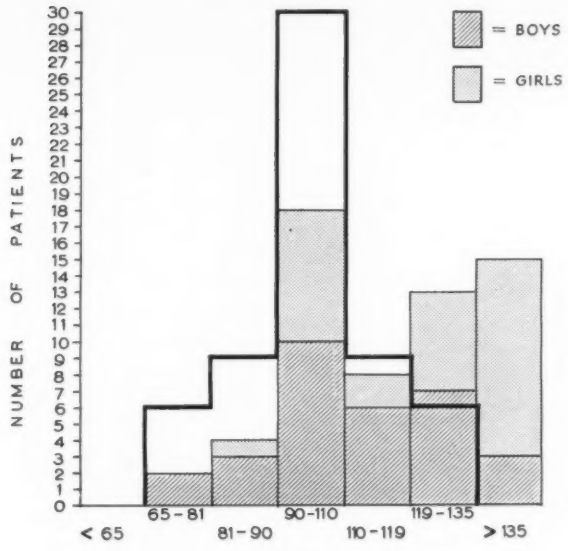


FIG. 5

The index of weight for the sixty patients whose weight was recorded, set out like the index of height in Figure 3.

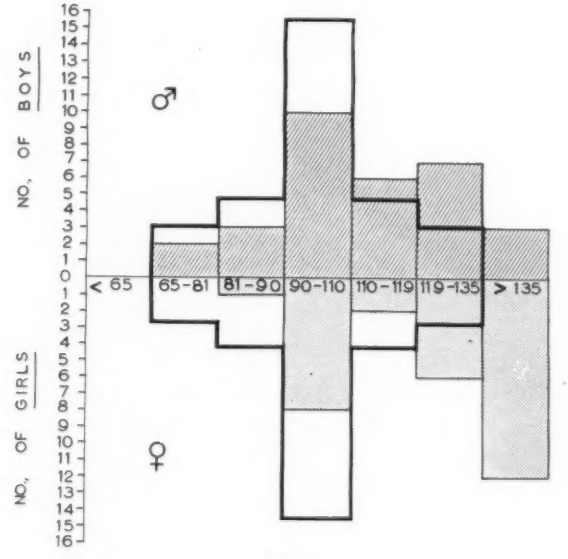


FIG. 6

As Figure 5, but plotted as in Figure 4, with boys shown above the line and girls below it.

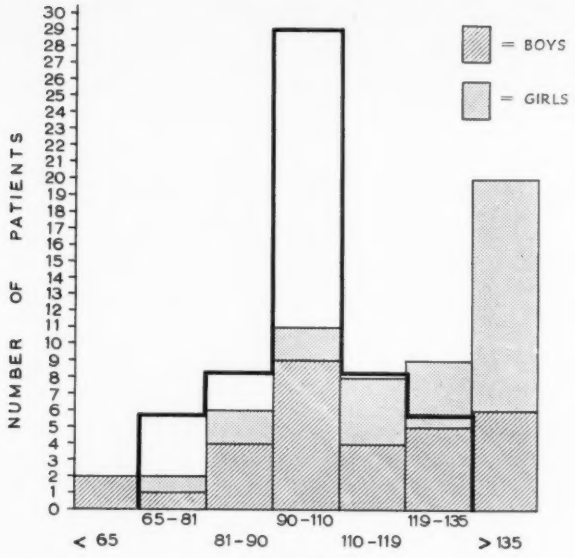


FIG. 7

The index of build (weight in relation to height) of the fifty-eight patients for whom the data were available, set out like the indices of weight and height in Figures 3 and 5.

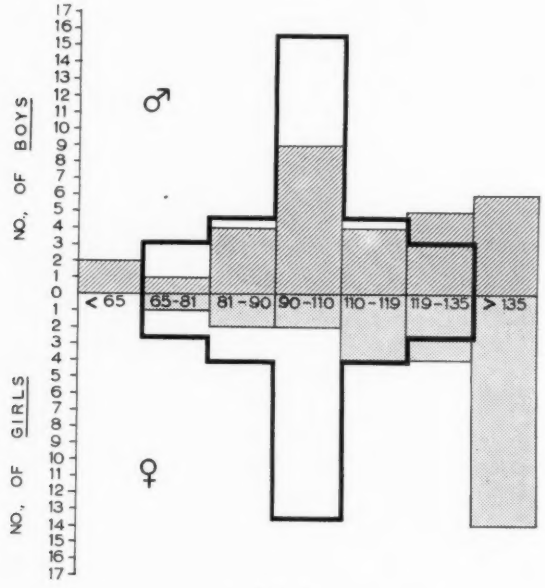


FIG. 8

As Figure 7, but set out like Figures 4 and 6, with boys shown above the line and girls below it.

Weight—Figures 5 and 6 are similar diagrams for indices of weight of the thirty-one boys and twenty-nine girls who were weighed. The deviation from the outline expected from plotting the same number of normal children is much greater in this instance than in the similar diagrams for index of height. The excess of *unusually* heavy and of *abnormally* heavy (index over 135) is much more pronounced than the corresponding excesses of tall people. In fact two somewhat overlapping groups emerge: 1) To the right a large group of overweight children, many of them *abnormally* heavy (index over 135) and others merely swelling the numbers of those *unusually* heavy; 2) a group of children normally distributed as to weight provided the group is shorn of the abnormally heavy and some of the unusually heavy comprising group (1).

The distribution of the readings of the index of weight does not admit of any ready explanation except the existence of two distinct groups of patients, one comprising those of average weight for their age and another comprising those who are overweight, with perhaps about an equal number in each.

A similar explanation is possible for the distribution of the index of height, but with much more uncertainty.

Weight in relation to height (*build*)—By the use of indices we can go further than relate the height of a child to the expected range in a hundred normal children of the same sex and age, or alternatively do the same for weight: from the height and weight indices an index can be prepared that in effect relates the weight of the child to the expected range of weights among a hundred children of the same sex, age *and height*. This is known as the Index of Physique or, better, the Index of Build (B.I.). It has been possible to compute this for thirty-one boys and twenty-seven girls, and the results are shown in Figures 7 and 8. The index of build exaggerates the grouping found for weight, and there emerge 1) a group of the unusually and abnormally sleek and 2) a group of normal build, and also seemingly a very small third group 3) of the abnormally lean or underdeveloped. This was made up of two boys with one-sided non-traumatic slipping. One was fifteen and three-quarters years of age, 5 feet $5\frac{3}{4}$ inches in height, and only 6 stones 10 lb. (94 lb.=43 kilograms) in weight; he had no evident endocrine defect and excreted 9·1 milligrams and 8·2 milligrams respectively of ketosteroids (as dehydroandrosterone) in twenty-four hours. The other boy, sixteen years of age, 5 feet 4 inches in height, 6 stones 4 lb. (88 lb.=40 kilograms) in weight, was considered to be of " Lorain type," with scanty pubic hair and slight widening of the lower radial epiphyses but a broken voice and a urinary ketosteroid excretion of 7 milligrams daily.

Comment—In so far as the data are correct, the indices of height and weight give a wholly reliable picture. The index of build should be accepted with greater reserve, because it depends upon a contestible formula: B.I.=$\frac{1}{2}$ (3 W.I.—H.I.).

Sexual development—Replies about the development of the sex organs and of secondary sexual characters have been vague and sometimes contradictory. Evidence of delay or arrest was said to be present in ten and possibly another five, and absent from seventy-three, but these figures are unreliable.

Menstruation—Information is available for thirty-eight of forty girls (Table II). Among twenty-eight who had slipping of only one epiphysis the menstrual state is unreported in two, two had begun to menstruate from five to fourteen months before, and the remaining twenty-four had never menstruated. Of twelve girls who had slipping of both upper femoral epiphyses, none had menstruated before the first side gave trouble and at least seven had still not menstruated when symptoms began on the other side; by then one had had a scanty flow one or two months before. It is not known whether the remaining four patients with slipping of the epiphyses on both sides had or had not begun menstruating when slipping on the second side began. Menstruation was reported in some patients to begin five or six months, a year or even three years after slipping of an epiphysis.

It may be concluded that a girl who menstruates is almost immune from slipping of the upper femoral epiphysis.

TABLE II

MENSTRUAL STATE IN RELATION TO ONSET OF SLIPPING

Hips affected	Number of patients	Number who had menstruated	Number who had not menstruated	Menstrual state unknown
One . .	28	2	24	2
Both . .	12			0
First side .		0	12	0
Second side		1	7	4

Urinary ketosteroid excretion is an index, of sorts, of androgenic activity. The twenty-four-hour excretion of 17-ketosteroids was estimated in twenty-four patients of the series—thirteen boys and eleven girls. The figures (Tables III and IV) are not very informative, because the range of " normal " is so wide.

Presence or absence of endocrine defect—We have tried to distinguish patients with possible endocrine imbalance from those not suspect.

In order to draw distinct dividing lines we arbitrarily ascribed to endocrine defect all patients labelled " Frölich " and the one patient labelled " Lorain " and all patients having an abnormally high (more than 135) index of build*; this is to say all those too heavy to be expected among a hundred normal children of the same age and height.

All heavy patients with an " unusual " (index of 119–135) but not " abnormal " weight were separately listed as overweight. These were children who would be among the heaviest ten of a typical hundred normal children of the same sex, age and height.

The dividing line between the two groups is quite arbitrary, depending really upon the degree of overweight, except when the notes gave a definite pronouncement. Even this was not wholly reliable without a knowledge of the surgeon's assessment of Frölich's syndrome.

It has been possible to make a list of constitutionally " normal " patients without any gross deviation of weight or any other evidence of endocrine defect.

We did not rely on such things as secondary sexual characters, unusually thick epiphysial plates or the urinary excretion of 17-ketosteroids, because standards at about the time of adolescence are so variable.

Three abnormally tall patients were encountered (besides the pituitary giantess reported in a separate section), so tall as to exceed the stature of all of a hundred typical normal children of the same age. Two of them were also overweight for their height.

There were twenty-seven children who could not be assessed for lack of data, but were probably nearly all constitutionally normal.

Table V suggests that endocrine defects were commoner in the girls, but the large number of boys whose condition could not be assessed makes the figures uncertain.

Rather unexpectedly, no striking relationship was found between constitutional factors and bilateral affection (Table VI), but, here again, the number of unassessed cases makes interpretation doubtful.

Epiphysial maturation—Control radiographs of wrist and hand (to be taken synchronously with that of another subject of like age and sex) were requested, to provide evidence of osteoporosis, retardation of ossific centres or thickening of epiphysial plates. Twenty-nine patients were so examined, with mainly negative results. Osteoporosis was found in two cases,

* All but two had a similarly abnormal index of weight.

TABLE III

URINARY KETOSTEROID EXCRETION—BOYS

Patient	Age	Physique	Type of slip	Urinary ketosteroid excretion *milligrams/24 hours*	"Normal" for age
K. B.	12½	Rather tall. Weight normal for height	?	7·4	3–10
T. M.	14	S2–	G	0	6–16
M. D.	14	"Normal"	S	10·7	6–16
R. S.	14	Slightly tall. Normal weight	S	14	6–16
M. H.	15	Slightly fat. Normal weight. Slight gynaecomastia	G	8·0	7–17
B. S.	15	Normal height. Abnormally heavy	S	7·7	7–17
J. W.	15	"Average build." No obesity	G	6·3	7–17
G. W.	16	Rather short. Unusually light. "Lorain" type	G	7	8–23
R. K.	16	Normal height. Unusually light	G	9·1, 8·2	8–23
M. C.	16	Fat striae	G	11	8–23
A. McC.	16	Rather tall. Normal weight	G	18·1	8–23
H. O.	17	Normal weight. Rather thin	G	14·9	8–23
B. M.	18	Seemingly normal weight and height	G	11·5	8–23

TABLE IV

URINARY KETOSTEROID EXCRETION—GIRLS

Patient	Age	Physique	Type of slip	Urinary ketosteroid excretion *milligrams/24 hours*	"Normal" for age
M. F.	9	Slightly tall. Very heavy	G	4	
C. B.	9	Very tall. Very heavy. "Frölich" type.	G	4	
I. B.	11 12	Normal	S	2·7, 3·4 5·6, 6·4	2–11
J. E.	11	? Slightly overweight	G	7·4	2–11
N. C.	11	Slightly tall. Very heavy	G	18·2	2–11
J. C.	11	Rather tall. Very heavy	G	1·3	2–11
R. B.	11	Very tall. Very heavy	G	19·1	2–11
B. H.	12	* Average	G	3	2–11
J. H.	12	Normal	S	9·3, 11·9	
D. L.	13	?	G	2·4	
G. F.	13	Slightly short. Rather fat. "Frölich type."	G	12·7	

* The only patient menstruating.

TABLE V

NUMBER OF PATIENTS WITH AND WITHOUT SEEMING ENDOCRINE DEFECT

	Boys	Girls	Total
Number with presumptive evidence of endocrine defect	11	20	31
Number with unusual, but not abnormal, weight	7	5	12
Number constitutionally seemingly normal	22	8	30
(Number not assessed)	(20)	(7)	(27)

TABLE VI

POSSIBLE CONSTITUTIONAL FACTORS IN BILATERAL AND UNILATERAL AFFECTION

	Bilateral	Unilateral	Total
Presumptive endocrine defect	9	22	31
Unusual (but not abnormal) weight	2	10	12
Constitutionally normal	10	20	30
Total assessed	21	52	73
(Not assessed)	(2)	(25)	(27)
Total	23	77	100

TABLE VII

FEMORAL UPPER EPIPHYSIAL PLATES
(Unilateral cases)

	Thickened	Not thickened
Side of slip	42	27
Other side	2	51

TABLE VIII

CORRELATION OF THICKENING OF EPIPHYSIAL PLATE WITH OTHER EVIDENCE OF ENDOCRINE DEFECT

Thickened plate	Patients with (other) presumptive evidence of endocrine defect	Patients of unusual but not abnormal weight	Patients constitutionally seemingly normal	(Number not assessed)	Total
Lower radial	*2	1	2		5
Upper femoral opposite to side of slip	0	0	1	(1)	2

* One " Frölich," one " Lorain."

but in another the density was greater than in the control. Only one patient showed evidence of retardation of ossific centres. The radial epiphysial disc was thickened (usually slightly) in five, narrower than the control in one, and in twenty-one cases there was no difference. (In one case the epiphysis was excluded from the film.)

A less reliable check on epiphysial maturation generally was provided by recording whether slipping of one femoral epiphysis was accompanied by thickening of the opposite epiphysial plate. Although, in unilateral cases, the disc on the affected side was reported to be thickened much more often than not (in forty-two cases out of sixty-nine) the opposite disc was observed to be thickened only twice in fifty-three cases (Table VII). At first sight this seems inconsistent with any important endocrine (and therefore general) factor in slipping of the femoral epiphysis; but there is the possible fallacy that an increased clear band on the side of the slip may represent something more than just thickening of the disc, so that slight thickening on the seemingly normal side might be masked for want of a reliable standard for comparison.

Nevertheless the evidence is against any general thickening of epiphysial discs in most of these cases.

We have failed to find any constant relationship between thickening of the epiphysial plate of the radius or of the undisplaced femoral epiphysis and other evidence of endocrine disturbance (Table VIII).

INJURY

History of injury—The questions about injury were answered in ninety-five instances. In thirty-eight there had been a recent injury seemingly involving the hip, and in an almost equal number there had been no injury at all (Table IX).

TABLE IX

HISTORY OF INJURY

Relevant		
before onset	19	38
at onset	19	
after onset	11	
Not relevant	6	44
None	38	
Indefinite	2	
(Unrecorded)	(5)	

Types of injury—The injuries were of the same type both in those who suffered a sudden epiphysial slip and in those with a gradual one. Much the commonest accident was a fall, often directly on to the affected hip, but sometimes on the thigh, knee or foot. The other common accident was a wrench. The common sources of both kinds of accident were: a variety of games; stumbling or slipping on stairs, steps or the level; and falls from bicycles.

Relation of injury to sudden or gradual epiphysial slip—In thirty patients (fourteen boys and sixteen girls) the slip seems to have occurred suddenly, but in seven (five boys and two girls) of these there had evidently been previous gradual slipping.

In fourteen patients (six boys and eight girls) the sudden slip could be called " acute "; that is to say that the patient was immediately disabled by pain and muscle spasm. In six patients (three boys and three girls) this acute slipping was preceded by symptoms of gradual slipping. In two girls, a sudden slip seemed to be followed a few days later by a further slip,

this time acute. The former of these patients, aged thirteen, suffered initial pain and disability when she tripped and twisted her hip running, and sustained the acute slip seventeen days later stepping from a high kerb; the second, aged twelve, sustained the initial slip in a fall on the left hip and the acute slip eight days later when she tripped and twisted the hip.

TABLE X

HISTORY OF INJURY IN RELATION TO TYPE OF SLIP

	History of seemingly relevant injury	No relevant injury
Sudden slip	26	4
Gradual slip	23	40

There appeared to be a relevant injury in twenty-six (fourteen boys and twelve girls) of the thirty patients with sudden slipping; and in thirteen (seven boys and six girls) of the fourteen patients with "acute" sudden slipping.

Relation of injury to endocrine type—That most or all of these injuries were relevant there seems little doubt; the genuinely doubtful ones have been rejected. What is impossible to say is which, if any, of them would be adequate to separate a normally firm epiphysis.

TABLE XI

HISTORY OF INJURY IN RELATION TO ENDOCRINE TYPE

	History of seemingly relevant injury	No relevant injury
Patients *with* seeming endocrine defects	9	18
Patients of unusual but not abnormal weight	7	5
Patients *without* evident endocrine defect	11	23

We have attempted to relate presence or absence of a history of injury with endocrine type (Table XI).

These figures do not suggest that relevant injury plays either a bigger or a smaller part in the patient with evident endocrine defect than in the patient without.

TABLE XII

ONSET OF PAIN IN RELATION TO LIMP

Simultaneous pain and limp	51
Pain first	20
Limp first	15

TABLE XIII

SITE OF ONSET OF PAIN

Hip region	60
Knee region	22
Hip and knee simultaneously	8

CLINICAL FEATURES

Pain and limp, the cardinal symptoms, started simultaneously in about half the recorded cases; in the rest pain preceded limp more often than vice versa (Table XII).

Contrary to text-book statements, pain began much more often about the hip than about the knee, and occasionally at both (Table XIII).

Both pain and limp more often started gradually than suddenly. Pain was more often intermittent than continuous; limp the reverse (Table XIV).

Wasting—Surprisingly, demonstrable wasting was almost as often absent as present (Table XV).

Shortening—More than half the patients presented shortening of half an inch or more, a few as much as one inch and over (Table XVI).

TABLE XIV

ONSET AND CHARACTER OF PAIN AND OF LIMP

	Pain	Limp
Onset		
Gradual .	55	56
Sudden .	31	18
Character		
Continuous	37	58
Intermittent	46	27

TABLE XV

WASTING

Present	40
Absent	39
(Unrecorded) . . .	(21)

TABLE XVI

REAL SHORTENING

No measurable shortening .	31	
Measurable shortening		
$\frac{1}{4}$ inch . . .	9	
$\frac{1}{2}$ inch . . .	28	
$\frac{3}{4}$ inch . . .	9	
1 inch or more . .	11	
	—	57
(Unrecorded)		(12)

Other deformities—As usually supposed, lateral rotation was the commonest deformity, occurring in about half the cases, usually alone but sometimes combined with adduction and more rarely flexion. Adduction was found in less than a quarter of the cases, nearly always in combination with lateral rotation deformity. Contrary to text-book teaching flexion deformity was sometimes found, but almost never alone (Table XVII).

Stiffness—Limitation of movement has been classified into slight, moderate and great by a thoroughly unmathematical method that proved unexpectedly easy to apply. Slight implies

the small limitation that a specialist should detect but that a well-trained but unaccustomed general man could pardonably miss. Moderate stiffness implies substantial limitation of several movements that any decently trained practitioner should detect. Great stiffness implies a negligible range or near it (Table XVIII).

TABLE XVII

DEFORMITY

	Lateral rotation	Adduction	Flexion
Alone	33	1	1
With lateral rotation only	—	14	2
With adduction only	14	—	3
With flexion only	2	3	—
Part of rotation, adduction, flexion deformity	5	5	5
Total	54	23	11

TABLE XVIII

LIMITATION OF HIP MOVEMENT

Slight	36
Moderate	26
Great	36

TABLE XIX

EXTENT OF DISPLACEMENT, AS SEEN IN ANTERO-POSTERIOR AND LATERAL VIEWS, IN RELATION TO EVIDENCE OF NECROSIS

Displacement	Antero-posterior view		Lateral view	
	Number	Necrosis	Number	Necrosis
Minimal	37	2	24	1
Quarter diameter	21	1	25	1
Half diameter	21	1	27	1
Three-quarters diameter	7	1	5	1
Whole diameter	7	0	7	0
Totals	93	5	88	4

RADIOGRAPHY

The epiphysial plate of the affected femoral epiphysis appeared thickened in rather more than half the cases in which its appearance was reported. Contrary to expectation the opposite plate, in unilateral cases, has only occasionally been demonstrably thickened.

In agreement with common supposition, displacement of the epiphysis has tended to be rather more evident in lateral than in antero-posterior films.

Radiological evidence of avascular necrosis was exceptional at the time of first examination and seemed unrelated to the extent of slip (Table XIX), but no deduction can be made because radiological diagnosis of avascular necrosis in the early months is unreliable.

The probable duration of symptoms before observation in the five cases in which there was initial radiographic evidence of necrosis was: six weeks, four months, four months, five months and a year. In two there was no injury; in one an injury preceded symptoms; in another it coincided with slipping; and in another it followed them. Slipping occurred gradually in three of the cases and suddenly in two.

DELAY IN TREATMENT

The ease of treatment, and almost certainly its results, depend so much upon early treatment that an investigation of the causes of delay seemed appropriate.

Definition—We have considered that there was delay if more than one month elapsed between the time that the symptoms began and the time that medical advice was sought, or if more than a month elapsed between the time advice was sought and the time efficient treatment began.

Causes of delay were: 1) parental procrastination; 2) diagnostic failure; 3) administrative failure; and 4) shortage of accommodation.

Parental procrastination caused delay of one and a half, two, two, three, five, five, seven and twelve months. The reason was often uncertain. The usual explanation offered was either that the condition seemed trivial or that it was ascribed to " rheumatism " and therefore accepted as a necessary evil. Certainly parental delay was confined to cases of gradual slipping. An only child was the victim of an over-solicitous mother who sought multitudinous advice and accepted none.

Diagnostic failure seems to have been responsible for delay of two to eighteen months in nineteen cases. In five (six weeks to one year, including a delay of four months in a patient in hospital for plastic surgery) no diagnosis seems to have been made. What is almost the same thing—a diagnosis of " rheumatism " was made in five cases, with delays of two, three, seven, twelve and fifteen months. Delays of one month, four months and one year were accounted for by diagnosis of muscle injury. In three cases attention was directed to the knee, to the exclusion of the hip, for five, ten and twelve months. Failure to detect radiological changes involved delay of four months, five months and eighteen months in three cases (Table XX).

TABLE XX

DIAGNOSTIC FAILURES CAUSING DELAY IN TREATMENT

Failure	Number of cases	Delay (*months*)
No diagnosis made . . .	5	1½, 4, 6, 9 and 12
Diagnosis of "rheumatism" .	5	2, 3, 7, 12 and 15
Diagnosis of muscle injury .	3	1, 4 and 12
Wrong joint (knee) suspect .	3	5, 10 and 12
Radiological changes undetected	3	4, 5 and 18

These depressing figures should be considered against the promptness in dealing with four-fifths of the cases and the deplorable conditions of overwork, inadequate assistance, overcrowding and obsolete accommodation under which much " Health Service " practice is conducted at present.

Administrative failures—Bad organisation and clerical errors accounted for delays of five weeks, six weeks and four months.

Shortage of accommodation—Four patients had to wait two months, two months, six months and eight months simply because beds could not be found for them.

SOME MISCELLANEOUS, PROBABLY IRRELEVANT, INVESTIGATIONS

The erythrocyte sedimentation rate was normal (equivalent to less than 10 millimetres/1 hour by Westergren method) in eleven cases, slightly raised (10–19 millimetres) in three cases and moderately raised (20–33 millimetres) in five cases.

The Wassermann (or equivalent) test was negative in the sixteen cases in which it was done.

With possibly one exception, the blood calcium and phosphorus were normal in the eight cases so investigated. The alkaline phosphatase was normal in three cases and raised to 18·0 phenol units (normal 5–15) in one.

CASES OF SPECIAL INTEREST NOT IN THE SERIES

Case 1, in pituitary giantess (Mr R. J. W. Withers's patient)—A girl of fourteen years, a sample-maker, was thin but 5 feet 11½ inches tall, was without dietetic fads and had not begun to menstruate. Soon after hospital investigation for pituitary disorder she complained of pain in the right knee for three weeks and in the right hip for a few days. She presented 60 degrees lateral rotation deformity of the right hip, with great restriction of all its movements. Radiographs showed slipping of the femoral epiphysis (a quarter circumference in antero-posterior view, a quarter to a half in lateral view) without evident thickening of the disc. She was treated by traction for three months and by caliper for six months till epiphysial fusion began, without further slipping. Twenty-two months from the onset she had no symptoms and an almost full range of movement, and she was 6 feet 3 inches tall.

Case 2, in pituitary hypogonadism: slipped upper femoral epiphysis at the age of thirty-three years—An unmarried medical librarian, aged thirty-three, a victim of hypogonadism, fell heavily from a bicycle on to his right knee. He had no pain till, two hours later, on rising from sitting, he could hardly bear weight on his right leg because of pain in the right hip. Nevertheless he went on a cycling holiday, but increasing pain and limp caused his admission to hospital seven months later, where the hip was treated by weight traction and then a walking caliper, and he received testosterone for six to eight months. Eight years later there was an inch of real shortening above the trochanter and 45 degrees of lateral rotation deformity of the hip; except for absence of medial rotation and abduction, movements were almost full. Radiographs confirmed old slipping of the upper femoral epiphysis (about a quarter of its circumference as seen from in front). The epiphyses at the upper ends of the femora had united, the lower only just; the lower radial and ulnar epiphysial plates were still open, but those of the metacarpals and phalanges had fused. The patient was 5 feet 5 inches in height and weighed 8 stones 5 lb. (117 lb. = 53 kilograms) clad. His testes were descended but small. His skin was dry, his face wrinkled and sallow, and he was almost hairless except on the scalp. His voice was normal. Further investigation was inopportune.

Case 3, with infantile paralysis of the opposite limb (Mr K. I. Nissen's patient)—A boy of fourteen years had suffered severe poliomyelitis affecting most of the right lower limb except the hip, but with little residual paralysis except in calf and foot, which presented talipes calcaneo-cavo-valgus. The left lower limb was seemingly unaffected, but a slip on stairs gave sudden pain in the left groin. Four days later all movements of the left hip were painful and it presented 45 degrees lateral rotation deformity. Radiography showed, in both antero-posterior and lateral views, slipping of the femoral epiphysis through half its diameter; the epiphysial disc appeared thickened on the left only, and the density of the head was not then increased. Almost complete reduction by nine days' traction with 15 pounds, and then nail fixation, were followed within three months by increasing density of the head and later deformity of avascular necrosis. The patient was tall (5 feet 8½ inches) but of normal weight (7 stones 12 lb. = 110 lb. = 50 kilograms) for his age, normally developed, showed some general osteoporosis and had a urinary excretion of 17-ketosteroids of 9 milligrams/24 hours.

Case 4, with Legg-Calvé-Perthes disease of the opposite hip (Mr R. W. Butler's patient)—A boy of seventeen, who had Legg-Calvé-Perthes disease of the right hip at the age of ten with little subsequent disability except limitation of rotation, suffered a slight twist of the left hip at the age of sixteen, followed by the gradual onset of constant aching pain which became suddenly worse seventeen months later, when the left hip showed lateral rotation deformity and poor movement. Radiographs revealed slipping of the upper femoral epiphysis amounting to a quarter of its diameter in the antero-posterior view and a half of its diameter in the lateral view. Manipulation and nailing gave a good result without evidence of avascular necrosis in the next ten months. The patient was fat, but normally developed.

Cases 5 and 6 in brothers (Mr R. W. Butler's patients)—A boy aged seventeen had suffered for six months from an intermittent pain in the left hip and limp of gradual spontaneous onset. Full flexion and extension were preserved, but medial rotation and abduction were totally abolished, and adduction and lateral rotation were halved. There was half an inch of real shortening and half an inch of thigh wasting. Antero-posterior and lateral radiographs showed slipping of the upper femoral epiphysis through a quarter of its diameter. A basal osteotomy with nailing gave, seven months later, a full range of painless movement, and the epiphysis had fused.

A month after this boy reported, his brother aged fifteen gradually began to suffer pain in the left knee. The hip showed the same radiographic abnormality as his brother's, but, presenting only four weeks' history, was treated by manipulation and a hip spica for three months. Nine months after the onset he had an excellent result with the epiphysis viable and fused.

SUMMARY

1. By questionnaire, an attempt has been made to ascertain the characteristics of a hundred cases of slipping of the upper femoral epiphysis.

2. The principal object has been to see whether an etiological classification would be possible pending an assessment of the results of treatment.

3. Proper statistical analysis has proved impossible because of the incompleteness of the data.

4. As usual, boys predominated and were usually affected as much as three years older than the girls.

5. It was exceptional to find epiphysial slipping in a girl once she had begun to menstruate.

6. Nearly a quarter of the cases were bilateral, or became so after six to twenty-four months or more.

7. Little information came from an enquiry about dietary fads, the estimation of urinary ketosteroid excretion in twenty-three of the patients, or some minor pathological investigations.

8. No convincing evidence was found of skeletal retardation or of general thickening of epiphysial discs, such as might perhaps be expected in a hormonal disturbance characterised by defective epiphysial maturation.

9. From each child with the necessary data, indices of height, weight and build were ascertained, which would indicate his expectation of finding a place among a hundred physically normal children of his own sex and age, and, if so, where that place would be. From these studies four groups of children seemed to emerge: 1) what may be called abnormally heavy children who would not find a place among a hundred, or somestimes a thousand, physically " normal " children of their own age and sex; 2) unusually heavy children who would find a place in the heaviest minority of the normal hundred; 3) a very small group of abnormally small people, among whom might be expected the subjects of pituitary infantilism; and 4) a large group of children of average physique for their sex and age.

10. From this information and from clinical evidence in the case returns, it appeared that a quarter of the assessable boys and nearly two-thirds of the assessable girls showed evidence of endocrine defect, quite apart from those who were merely unusually fat.

11. By distinguishing these two groups of children from a third group of constitutionally " normal," an attempt has been made to see whether there is any correlation between evident endocrine defect and such characteristics as bilateral affection, delayed epiphysial maturation, a history of relevant injury and its nature, and sudden or gradual epiphysial slipping.

12. No relationship was established between any of these characteristics and endocrine type: bilateral affection was no commoner in the endocrine group; delayed maturation was not demonstrated in either; a history of relevant injury was equally common, and its nature identical, in both; slipping might be sudden or gradual in either indiscriminately.

13. There was a history of seemingly relevant injury in half the patients, and it was much commoner with sudden slipping than with gradual slipping. Sudden slipping was often preceded by symptoms of gradual slipping, or sudden slipping of one epiphysis was sometimes followed by gradual slipping of the other.

14. In gradual slipping the cardinal symptoms were pain and limp, usually starting synchronously and gradually; the pain was usually intermittent and referred much more often to the hip than the knee; the limp was usually continuous.

15. Of signs, demonstrable wasting seemed to be absent as often as present, but shortening was usual. Lateral rotation deformity was usually present, adduction often, and flexion sometimes. In more than a third of the cases limitation of movement was slight enough to be easily missed.

16. The radiographic observations confirmed the seeming widening at the affected epiphysial disc, the greater displacement revealed by the lateral view, and the difficulty of identifying avascular necrosis before collapse.

17. Treatment was delayed in thirty-four cases—a third of the whole; the reasons have been analysed; diagnostic failure was the cause in nineteen.

18. A few cases outside the series have been mentioned briefly because of special points of interest: slipping in gross pituitary disease—in pituitary giantism, and (at the age of thirty-three) in pituitary hypogonadism; slipping with defect of the opposite lower limb—infantile paralysis of the leg, and Legg-Calvé-Perthes disease of the hip; familial affection—slipping in two brothers.

19. The results of treatment in the present cases, supplemented by others, have been studied by Dr John Hall and related to some of the clinical features. His paper appears separately.

PRINCIPAL CONCLUSION

An extensive study of a hundred cases of adolescent slipping of the upper femoral epiphysis has failed to demonstrate any fundamental difference in behaviour between those with manifest endocrine defects and those without. Consequently, and contrary to expectation, no classification based on the natural history of different groups has been possible.

The following surgeons, with their assistants, have kindly provided the material for this investigation and have given Mr John Hall every facility for follow-up. *Aberdeen*, Mr A. M. Rennie; *Bath*, Miss M. F. Forrester-Brown; *Belfast*, Dr H. P. Hall, Mr N. S. Martin, Mr R. J. W. Withers; *Cambridge*, Mr R. W. Butler, Mr T. J. Fairbank; *Canterbury*, Mr F. G. St C. Strange; *Carshalton*, Mr R. H. Metcalfe, Mr R. G. Thomas; *Derby*, Mr R. G. Pulvertaft; *Glasgow*, Mr R. Barnes, Mr R. D. Muckart; *Hairmyres*, Mr R. N. Traquair; *Leeds*, Mr R. Broomhead, Mr A. B. Pain, Mr T. Price; *Liverpool*, Mr P. B. Moroney, Mr R. F. O'Driscoll, Mr A. G. O'Malley, Mr N. W. Roberts, Mr E. N. Wardle; *London*, Mr J. S. Batchelor, Mr J. G. Bonnin, Mr B. H. Burns, Mr W. D. Coltart, Mr S. L. Higgs, Mr J. I. P. James, Mr P. H. Newman, Mr K. I. Nissen, Mr R. Y. Paton, Mr H. J. Seddon, Mr D. Trevor; *Manchester*, Mr S. M. Milner; *Nottingham*, Mr S. A. S. Malkin; *Oxford*, Mr W. B. Foley; *Windsor*, Mr G. P. Arden.

To all these, and especially to Dr John Hall, Mr E. N. Wardle and Dr A. McPherson, the collator is deeply indebted.

REFERENCES

HARRIS, W. R. (1950): The Endocrine Basis for Slipping of the Upper Femoral Epiphysis. An Experimental Study. Journal of Bone and Joint Surgery, **32–B**, 5.

SUTCLIFFE, A., and CANHAM, J. W. (1950): The Heights and Weights of Boys and Girls. London: John Murray.

THE RESULTS OF TREATMENT OF SLIPPED FEMORAL EPIPHYSIS

J. E. HALL, TORONTO, CANADA

From the Institute of Orthopaedics, Royal National Orthopaedic Hospital, London, England

In 1950 a sub-committee of the British Orthopaedic Association was formed under the direction of Mr H. Jackson Burrows and Mr E. N. Wardle for the study of slipped femoral epiphysis. A large number of surgeons filled in questionnaires about patients beginning treatment. A study of the early findings in one hundred of these patients forms the basis of a separate report, dealing principally with etiology and onset (Burrows 1957).

These patients, with the addition of thirty-eight others, have been observed for five years. The upper femoral epiphysis had slipped in 173 hips. All the patients have been interviewed and examined by the writer, who was able to peruse the old notes and radiographs in nearly every case.

Drawn from many centres, the material is heterogeneous and represents a random sample of the results in the United Kingdom in recent years.

THE METHOD OF ASSESSMENT

Shepherd's (1954) method of assessing the results of arthroplasties was adopted to classify the results of treatment of slipped femoral epiphysis, with the modifications necessary in much younger patients. The same four major tests were applied—pain, movement, functional activity and the patient's own assessment.

Since excellent function may be maintained in spite of radiographic changes that promise an early deterioration of function, it was considered that some attention had to be paid to the radiograph. For this reason sub-groups were added to the usual classifications of " excellent " and " good " to include those patients with present excellent or good function, but whose prognosis was judged on radiographic evidence to be nevertheless poorer than in the rest of the group. In most patients with excellent function the shape of the femoral head was preserved or restored, but in a few the femoral heads were deformed, there was severe varus or posterior angulation of femoral necks, the joints were narrowed or there was early osteophytic lipping of the joint margins. This discrepancy between radiographic appearance and function has been pointed out by Ratliff (1956).

Shepherd's tests are discussed below in more detail and the summarised system of assessment is shown in Table I.

Pain was a common complaint (29 per cent), but in only 5 per cent did it interfere in any way with normal activities. In no case was it found to be " disabling " or " crippling "; if it had been so in the past some secondary procedure had ameliorated it before the review.

The mobility index was determined from Gade's (1947) system of grading the various components of hip movement. In this system loss of medial rotation (the commonest residual defect) is not heavily penalised and may even be more than compensated for by the increased range of lateral rotation (Fig. 1). Other imperfections have been described by Jerre (1950) in his detailed monograph.

Gade's indices were calculated to produce an index of 100 for a normal hip, but in the writer's hands the index for fifty normal hips was just over 90, an indication of the great range of variation in the estimation of hip movements.

When a single hip was affected it was compared to the patient's own normal hip rather than to any arbitrary standard, and was considered to have an excellent range of movement

if its index differed by no more than five points from that of the unaffected side. When both hips were affected the index for each hip was compared to normal (90); anything within five points of this was considered excellent and within fifteen points good. Other values are shown in Table II.

Assessment by function—Black marks were allotted for selected activities that were difficult or impossible for the patient, and a total score was given. Not as much leeway was allowed for these young, otherwise healthy, people as for the older folk in Shepherd's series, so that

TABLE I

ASSESSMENT OF FUNCTIONAL ACTIVITY

Activity		Black marks
Limp	Yes	1
	No	0
Trendelenburg test	Positive	2
	Negative	0
Walking outside	Unaided	0
	Requires one stick	1
	Requires two sticks	3
	Requires two crutches	4
Distance walked	Not at all	4
	100 yards	3
	½ mile	2
	Over a mile	0
Completely bedridden		10
Putting on own shoe and sock	Yes	0
	With difficulty	1
	No	2
Stair climbing	Yes	0
	With difficulty	1
	No	3
Toilet	Yes	0
	With difficulty	1
	No	3
Bathing	Yes	0
	With difficulty	1
	No	3
Work and activities	Heavy physical	0
	Moderate	1
	Light	2
	Slight	3
	None	4

(Reproduced from Shepherd, M. M. (1954): Assessment of Function after Arthroplasty of the Hip. Journal of Bone and Joint Surgery, **36–B,** 354.)

more than one black mark put a patient out of the " excellent " group and no more than three were tolerated for a rating of " good." Table I is reproduced from Shepherd's article and shows how black marks were apportioned.

The patient's own assessment was not a very good yardstick, perhaps because of the optimism of young people. Some patients were uncomplaining about results that by any other standard must be considered poor. The performance of the patients with ankylosed hips testified to the value of an arthrodesis, but an immovable hip must be considered a poor outcome of treatment.

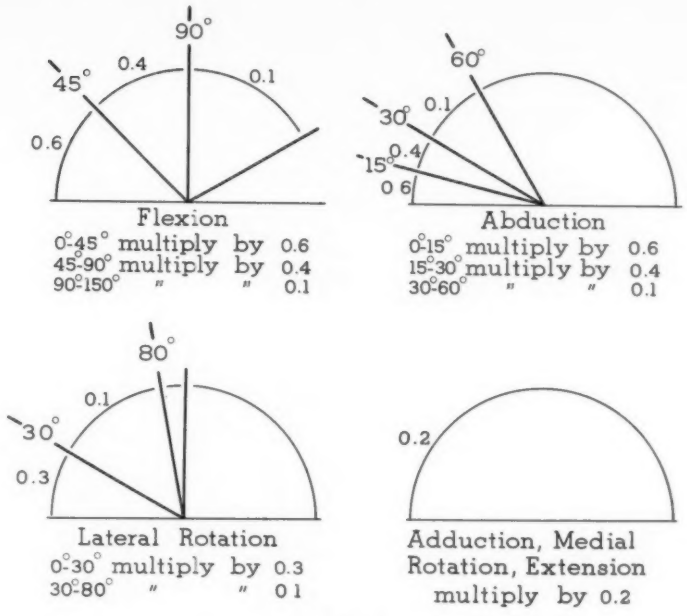


FIG. 1

Multiplication factors in Gade's calculation of Mobility Index (from Shepherd, Journal of Bone and Joint Surgery, **36–B,** 356). The movements that are most useful for everyday life are most heavily weighted; the first 45 degrees of flexion, 15 degrees of abduction and 30 degrees of lateral rotation are considered to be the most important. A normal hip should have an index of about 100.

TABLE II

SUMMARY OF FACTORS CONSIDERED IN ARRIVING AT FINAL ASSESSMENT

	Pain	Mobility index		Function by performance	Patient's own assessment	Radiographic evidence
		One hip affected	Both hips affected			
Excellent	"None" or "ignores"	Difference of **5 or less** between hips	**85 or over**	1 black mark	"Normal" or "very good"	Incongruent joint surfaces, residual gross displacement, osteoarthritic lipping or narrow joint space, caused hip to be placed in sub-group with poorer prognosis
Good	"None" or "ignores"	Difference of **6 to 20** between hips	**75 to 85**	Up to 3 black marks	"Good"	
Fair	Makes concessions	Difference of **21 to 40** between hips	**50 to 75**	Up to 5 black marks	Gives some trouble	
Poor	Disabling or crippling	Difference of **40 or over** between hips	**less than 50**	6 or more black marks	"No good"	

The result was recorded in the lowest category indicated by any single factor. Fair and poor results were almost always associated with radiographic evidence of gross deformity.

CHARACTERISTICS OF THE SERIES

Of the 138 patients examined, thirty-five were found to have both hips affected (25·4 per cent), making a total of 173 hips to be reported. There was a slight preponderance of males (54·3 per cent), and among the males a definite predilection for the left hip in unilateral cases (thirty-nine left *v.* seventeen right). This preference for the left hip was not apparent among the female group (twenty-five left *v.* twenty-two right). The significance, if any, of this finding is not known (Table III).

TABLE III

SIDE AFFECTED IN RELATION TO SEX

Male				Female			
Unilateral		Bilateral		Unilateral		Bilateral	
Right side	Left side	Right side first	Left side first	Right side	Left side	Right side first	Left side first
17	39	12	7	22	25	10	6

The average duration of observation was eighty-six months, ranging from three months to forty-three years; 82·8 per cent of the patients were seen four years or more after the beginning of their treatment.

Although this is not an etiological study the case histories of two patients are of some interest in relation to the question of whether an acute slip occurs in a previously normal epiphysis.

Case 55 (Mr R. N. Traquair's patient)—A boy aged fifteen and a half years who had complained of pain in his right hip for eight weeks, was sent for radiography. After the antero-posterior film had been taken his hip was flexed and abducted for the lateral picture. This manoeuvre caused severe sudden pain. The antero-posterior film showed a minimal slip, and subsequent films showed a complete one.

Case 100 (Mr H. P. Hall's patient)—A girl aged twelve and a half years having limped for three weeks had an antero-posterior radiograph taken. While leaving the x-ray room she tripped and fell. As in the previous case, the first film showed a minimal slip, subsequent films a complete one. It is suggested that whether the onset shall be gradual or acute is a matter of chance.

TABLE IV

RESULTS

Category	Percentage of cases	Remarks
Excellent	48·3	1 in 12 were considered on radiographic evidence to have a less than excellent prognosis
Good .	29·6	1 in 5 had radiographs indicating an unfavourable prognosis
Fair .	6·9	
Poor .	15·2	

RESULTS OF VARIOUS TREATMENTS

By the criteria set out in Table II the results fell into the groups shown in Table IV.

The difficulties in assessment were legion, partly because the work of a great many surgeons is represented, each doing something just a little different. The patient was often

subjected to more than one type of treatment (for instance, a period of traction followed by a manipulation and an operation), so that it was difficult to judge the contribution of each to success or failure. Notes were often inadequate and the patient's recollection was seldom precise, so that conflicting accounts of the type of onset were not rare.

To facilitate discussion and comparison, the series has been broken down into several broad groups. The results obtained in these groups have been summarised in Table V and will be discussed more fully below.

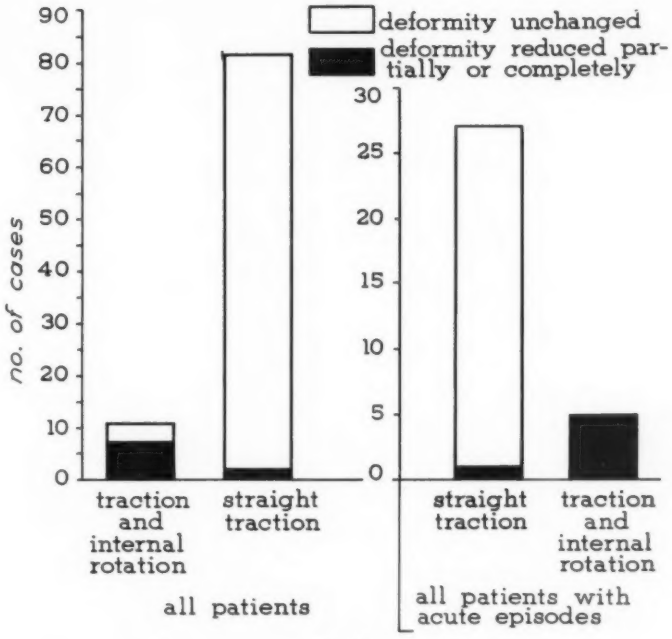


FIG. 2

A composite chart showing the value of medial rotation combined with traction. The left side of the chart shows that much greater success follows the use of medial rotation with traction than the use of traction alone. On the right side of the chart the patients who had histories of acute episodes are segregated. It can be seen that this group contains six of the nine patients in whom the displacement was successfully reduced. All five patients with acute episodes who were treated by traction plus medial rotation had their deformities reduced.

NON-OPERATIVE TREATMENT

Non-operative treatment included among other things traction in recumbency, immobilisation in a plaster spica, the use of a weight-relieving caliper, or just simple rest in bed. The results then depended on the initial degree of displacement, because it was not usually changed by these methods.

Three types of non-operative treatment did make some difference; these were manipulation, traction combined with medial rotation, and forced abduction on a frame.

Forced abduction was used on five occasions on hips that could not be passively abducted. Avascular necrosis followed in three of these, with a poor result in a fourth.

Traction was the most commonly used form of treatment, being recorded in ninety-two cases, either as the definitive treatment or as a preliminary to some other method. Since serial radiographs were usually taken of patients treated by traction, it was evidently hoped

that it would lead to a diminution in the displacement. This hope was realised in just under 10 per cent of cases. Two factors were found to be of paramount importance: 1) whether or not medial rotation was used; and 2) the type of onset.

The most common residual deformity, as well as one of the earliest signs of this disease, is a limitation of medial rotation. This suggests how the deformity is produced and that attempted reduction should include some method of applying medial rotation.

In only eleven instances out of the ninety-two was specific mention made of medial torsion as part of the traction apparatus, and in seven of those the deformity was partly or

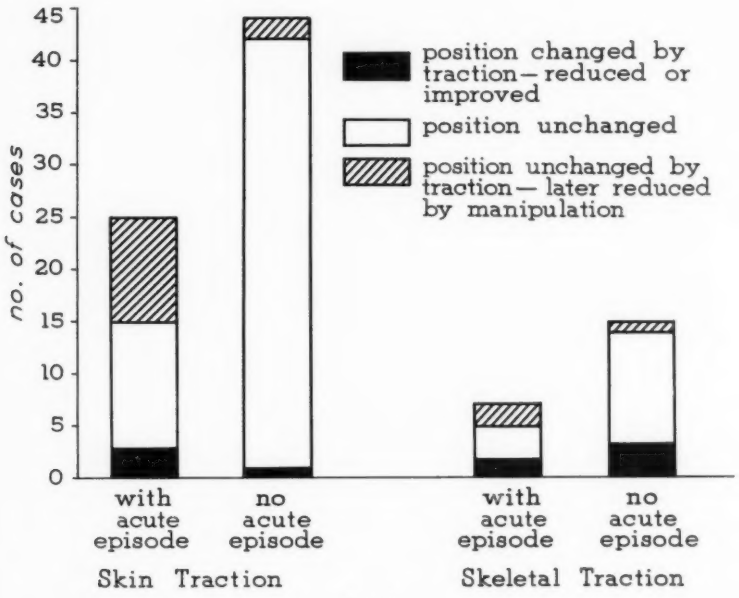


FIG. 3

The efficacy of traction in reducing deformity. Skin and skeletal traction are compared, and the importance of the history of an acute episode is shown. Patients with an acute episode treated by skin traction seldom had any change in their deformity, but subsequent manipulation was often successful. In patients who had no acute episode, neither traction nor manipulation had any great success. Skeletal traction was slightly more successful but the same principle holds.

completely reduced. Of the other eighty-one, presumably treated by straight longitudinal traction alone, the deformity was reduced in only two (Fig. 2). Perkins (1932) found that straight traction alone would reduce the deformity in early cases of sudden onset.

A factor that seems important in determining the possibility of closed reduction is the history of a recent acute episode (Foley 1946, Vaughan-Jackson 1956). To be significant, this episode should have been severe enough to prevent walking for several days. Such was the case in thirty-two patients treated by traction begun a few hours to several weeks after the episode. Twenty-seven of these were treated by straight traction, with success in only one case. The other five were treated by traction combined with medial rotation for one or two days, and in all five the deformity was reduced partly or completely (Fig. 2). Of the sixty patients who gave no history of acute episodes, traction changed the displacement in three.

Skeletal traction, employed seventeen times, succeeded slightly better than skin traction

in reducing displacement. The Steinmann pins, whether in the lower end of the femur or in the upper end of the tibia, did no harm; the range of knee movement was diminished in three cases only, by 10 degrees or less.

Figure 3 is a composite chart showing the relative effectiveness of skin and skeletal traction, and also showing that manipulation was used to reduce the deformity after traction had failed in fifteen cases.

Manipulation under a general anaesthetic was recorded in thirty-three cases, either as part of non-operative treatment or as a prelude to operation. Some success in changing the

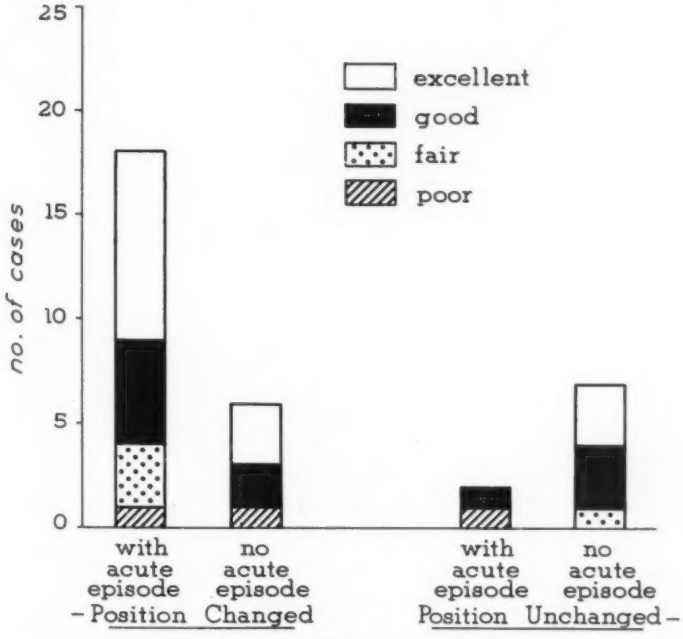


FIG. 4

Results of treatment by manipulation. This table shows that most patients whose deformities were reduced by manipulation had acute episodes in their history. Of the patients whose deformity was unchanged, only a small proportion had had an acute episode. The table shows also that a good proportion of satisfactory results can follow manipulation done in the right type of patient.

relationship of the epiphysis to the metaphysis was obtained in twenty-four hips, and no change could be detected in the other nine.

The manipulation consisted in strong medial rotation applied with longitudinal traction. This was accompanied in several instances by forced abduction, and there is some evidence that this is not only unnecessary but may be harmful to the epiphysial blood supply.

Patients with a recent acute episode had the best prospect of epiphysial reduction by manipulation. Of the nine in whom this failed, only two had had acute episodes, and these had occurred more than a month before. Eighteen of the twenty-four in whom manipulative replacement had been achieved had reported an acute onset or an acute episode after a period of minor hip disability.

Kleinberg and Buchman (1936) condemned manipulation even in recent cases with an acute onset, stating that avascular necrosis was the usual sequel.

Subsequent epiphysial avascular necrosis was observed in three cases of successful reduction. In two there had been no acute episode. A Smith-Petersen nail was used in one of these and in the third case.

In two cases in which the manipulation was unsuccessful the epiphysis underwent avascular necrosis.

Twenty of the patients treated by manipulation had suffered a recent acute episode, and in eighteen of them the manipulation was partly or completely successful in reducing the deformity.

Thus it seemed that a firm gentle manipulation was a relatively safe and effective way of reducing the displacement in a case seen within a few weeks of an acute episode.

These findings are summarised in Figure 4, which shows the results obtained after successful and unsuccessful manipulation in patients with or without an acute episode.

OPERATIVE TREATMENT

Smith-Petersen nails or other large trifin nails were used on eighty-four occasions, thirty-six times after cervical osteotomy and forty-eight times either as primary treatment or after a period of traction or a manipulation.

The results were generally satisfactory, but complications were found in a surprisingly large number of patients.

Avascular necrosis—In the cases of nailing without any direct attack on the femoral neck there were five examples of avascular necrosis. Brief case reports on the patients are as follows.

Case 5A—A boy aged fifteen years at onset in August 1953 had complained of pain in his right knee and of a limp for five months. The pain became worse in December 1953 after a fall, and in January 1954 a Smith-Petersen nail was inserted. No mention was made of a manipulation in the operation note, but some change was noted in the position by radiography after operation. Avascular necrosis was noticed two months later, beginning in the segment near the tip of the nail. An arthrodesis was performed in April 1955.

Case 18—A boy aged fourteen in October 1950 sustained in an accident a left femoral supracondylar fracture and a completely separated upper epiphysis. With ten days' skin traction this was reduced. A Smith-Petersen nail was inserted and weight bearing was begun after fourteen weeks. He had no complaint until January 1953 when his left hip became painful. A radiograph revealed avascular necrosis, and a cup arthroplasty was performed in June 1953. In October 1955 the cup was removed and the head and neck of the left femur were excised, leaving a mobile, painless, reasonably stable hip. It is possible that this case represents a fracture-separation of the femoral epiphysis.

Case 38B—A boy aged sixteen at onset in October 1949 noticed pain in both hips while running for a bus. Radiographs showed a severe slip of the right femoral epiphysis with a minimal slip on the opposite side. He was placed on an abduction frame for ten weeks. In February 1950 a cervical wedge osteotomy was performed on the right side with Moore's pins for internal fixation. In March 1950 a simple nailing with a Smith-Petersen nail was done on the left hip. Both epiphyses subsequently became avascular, and in retrospect it could be seen that the joint spaces were narrow before operation. Virtually all hip joint movement was lost on both sides, and cup arthroplasties were done, neither of which was successful.

Case 49—A boy aged fifteen suffered in October 1951 a complete sudden slip which was treated by a manipulation and Smith-Petersen nailing. Avascular necrosis followed. A cup arthroplasty in October 1952 was not successful; and an arthrodesis was performed in May 1954.

Case 120B—A girl aged thirteen suffered minimal slipping of the right femoral epiphysis in February 1949. A Smith-Petersen nail was inserted. In August 1950 she suffered a sudden complete slip on the left side, which was treated by a manipulation and Smith-Petersen nail. Radiographs at three months were suggestive of avascular necrosis, and weight bearing was deferred for two years until there was evidence of revascularisation. The functional result is now good.

It may be noticed that in each of these cases some other factor must share responsibility with the Smith-Petersen nail. It may be that the added trauma of driving a large nail into the femoral head may be enough to abolish completely an already precarious blood supply (Howorth 1949, Jerre 1950). Possibly the blood supply of an epiphysis that could survive

either a manipulation or a Smith-Petersen nailing would occasionally find the combination lethal. Such was the case in three of the eight patients in whom this combination was used. With this in mind, Cleveland, Bosworth, Daly and Hess (1951) suggested a delay between reduction and fixation.

Subtrochanteric fracture through the cortex penetrated by the Smith-Petersen nail (Klein, Joplin, Reidy and Hanelin 1953) had occurred in three cases. This complication happened with trivial injury between one and two months after a seemingly uneventful operation. In one case the nail was removed and the limb immobilised in plaster; in the other two the nail was replaced by a nail and plate. One of these was further complicated by fracture of the plate and non-union of the bone, but union was eventually secured by the use of a Küntscher nail and bone graft. The final result was excellent in all three.

Crack fracture of the femoral neck was produced at two operations but healed rapidly with no residual disturbance.

Gap between epiphysis and metaphysis—Radiographs after operation showed that the epiphysis had been driven about one-eighth of an inch away from the metaphysis in two patients, but in each the gap gradually filled with new bone and there was no evidence of disturbance of epiphysial blood supply.

TABLE V

RESULTS ACCORDING TO TYPE OF TREATMENT

	Total number	Excellent	Good	Fair	Poor
Non-operative: no manipulation	32	43·8%	34·4%	6·3%	15·6%
Non operative: with manipulation	11	27·2%	45·4%	18·2%	9·1%
Smith-Petersen nail	48	68·9%	18·8%	4·2%	8·4%
Moore's pins	20	80%	20%	—	—
Cervical osteotomy	42	23·7%	35·7%	4·7%	35·8%
Subtrochanteric osteotomy	9	22·2%	33·3%	22·2%	22·2%
Bone graft on anterior epiphysial line	3*	100%	—	—	—
No treatment	9	33·3%	44·5%	22·2%	—

* One of these continued to slip three months after operation and was further treated by Moore's pins—final result was excellent.

Moore's pins (Moore 1935) or other slender multiple pins were just as effective as Smith-Petersen nails in preventing slipping or maintaining reduction, and their use was seldom followed by complications (Blount 1945, Howorth 1949). They were employed twenty times, with no complication except erosion of two pins. In one case in which two non-threaded pins were inserted they backed out within four months of the operation, but no further slipping was noticed in spite of continued weight bearing. Table V, which shows only excellent and good results after pinning with Moore's pins, indicates a clear-cut seeming superiority of the small pins over Smith-Petersen nails. However, the patients treated with Moore's pins were under observation for an average of only 21·6 months, compared with 67·7 months for those treated with Smith-Petersen nails. It may be that avascular necrosis will eventually be evident in some of these patients, eight of whom had had successful manipulations.

When the position of the epiphysis has been changed by traction, manipulation or open reduction, there was general agreement that no weight should be borne on the hip for at least three months. Early weight bearing, within two weeks of the operation, was allowed in

eighteen patients after a minor degree of slipping had been accepted and fixed *in situ* by Moore's pins or a Smith-Petersen nail. In no case was there any cause for regret: an excellent result was found in twelve, and a good result in the other six.

Cervical osteotomy—This operation was recorded forty-two times. It was performed in a variety of ways by many different surgeons. The cases have been grouped according to the site and type of osteotomy and on the type of fixation. Figure 5 represents the results in each group. The number is rather small for hard-and-fast conclusions but some general ones are apparent. Contrary to some early reports (Whitman 1909, Key 1926), cervical osteotomy without internal fixation was almost uniformly disastrous. Avascular necrosis seemed to be least common after low cervical wedge osteotomy, in spite of good reports of the wedge at

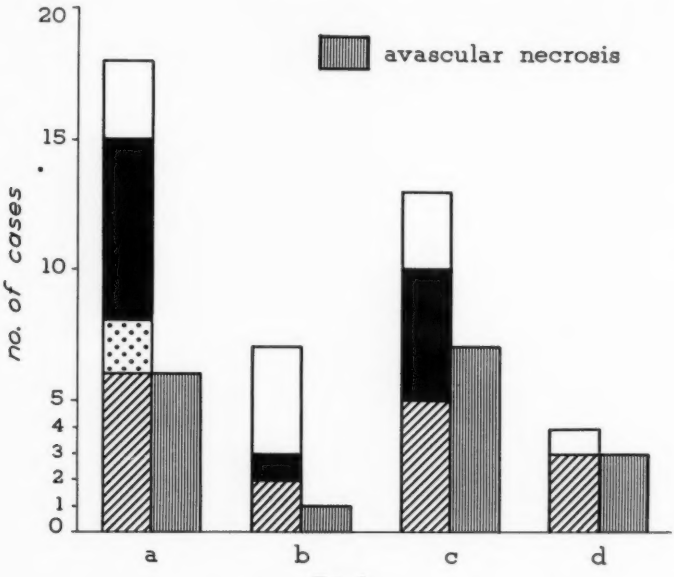


FIG. 5

Results of different types of cervical osteotomy. The same key as in Figure 4 has been used to show the proportion of Excellent, Good, Fair and Poor results. *Group a*—Osteotomy at the epiphysial line, with removal of a wedge of metaphysis: internal fixation with a Smith-Petersen nail. Avascular necrosis in 33·3 per cent. *Group b*—Wedge osteotomy low in the neck: internal fixation with a Smith-Petersen nail. Avascular necrosis in 14·3 per cent. *Group c*—Curved osteotomy at the epiphysial line but no wedge of bone was removed: fixation with Smith-Petersen nail, lag screw, bone peg or Moore's pins. Avascular necrosis in 53·8 per cent. *Group d*—Any type of cervical osteotomy, with or without removal of a wedge of bone: no internal fixation. Avascular necrosis in 75 per cent.

the epiphysial line (Kleinberg and Buchman 1936, Foley 1946, Martin 1948, Compere 1950, Cleveland *et al.* 1951, Klein *et al.* 1953).

A Smith-Petersen nail was used for internal fixation in thirty-six of the forty-two operations, and one cannot but wonder whether avascular necrosis (38·1 per cent) would have been any less common if some type of smaller pin had been used.

It is worth noting that three patients who showed radiographic evidence of avascular necrosis, and were kept off weight bearing for two years, now have hips that are regarded as excellent in one case and good in the other two.

Intertrochanteric osteotomy was employed nine times, usually when the epiphysis was solidly fused in the deformed position. The usual method of fixation was a plaster spica, but in the

one case in which internal fixation was used, with a nail and plate, the result almost qualified as excellent. The only poor result was in a case complicated by avascular necrosis. As there had been an unsuccessful manipulation before operation, it is difficult to incriminate the osteotomy.

Perkins (1932) advocated subtrochanteric osteotomy for late cases and those with a gradual onset; and lately there has been a revival of interest in this operation. Good results with little danger of avascular necrosis are reported.

Bone grafts across the epiphysial line (Howorth 1949) were used in three patients, who were confined to bed for three months after operation. Two had no further trouble. The third patient continued to have pain on weight bearing, and further slipping was demonstrated by radiography. Internal fixation with Moore's pins ended her symptoms, and all three patients had excellent final results.

Negligible treatment—Nine patients whose present radiographs show unmistakable evidence of a previous slipped femoral epiphysis in the reputedly normal side had no treatment for it, except bed rest while the opposite hip was treated. Most of them could not recollect any pain in the neglected hip. The present condition is shown in Table V; in general the result depended on the degree of displacement. It is interesting to speculate how many of the distorted osteoarthritic hips seen in older patients had their origin in unrecognised slipped femoral epiphyses.

TABLE VI

INCIDENCE OF AVASCULAR NECROSIS

Treatment	Percentage with avascular necrosis
Cervical osteotomies—all types	38·1
Smith-Petersen nail plus manipulation	37·5
Non-operative treatment without manipulation	12·5
Subtrochanteric osteotomy*	10·9
Non-operative treatment including a manipulation	9·1
Smith-Petersen nail without a manipulation	5·0
Moore's pins with or without a manipulation	0

* This represents one patient who underwent unsuccessful manipulation before operation.

Avascular necrosis occurred in 18·3 per cent of all patients subjected to manipulation.

Salvage operations were necessary in eleven patients, usually when the initial treatment ended in avascular necrosis. Four arthrodeses, four cup arthroplasties and three displacement osteotomies were done. The cup arthroplasties all failed; the arthrodeses, two of which had to be repeated, gave very good results.

FACTORS MODIFYING RESULTS

Avascular necrosis influenced the end result more than any other single factor. Of the twenty-seven patients with poor results, twenty had been victims of avascular necrosis. A poor result was not inevitable after loss of epiphysial blood supply, but was usual. The total number of examples of avascular necrosis was twenty-seven, an incidence of 15·6 per cent, and the result in all but seven of them was rated as poor. Of the other seven, the result in

three was fair, in three good, and in one excellent. One of those rated as good had radiographic evidence of an incongruous joint, but in the rest the joint looked practically normal. The patients with excellent and good results had all been treated by non-weight-bearing for about two years.

As Waldenström (1930) and more recently Moore (1945) and Jerre (1950) have suggested, avascular necrosis seemed to appear in two forms. In a minority of cases not only does the bony epiphysis lose its blood supply but there is also a massive necrosis of articular cartilage. The joint space is visibly narrowed before other radiological changes are evident, and the range of movement is seriously restricted. Eventually the joint space is completely lost, and the result is an ankylosed hip. In the other type, although the joint space may be decreased,

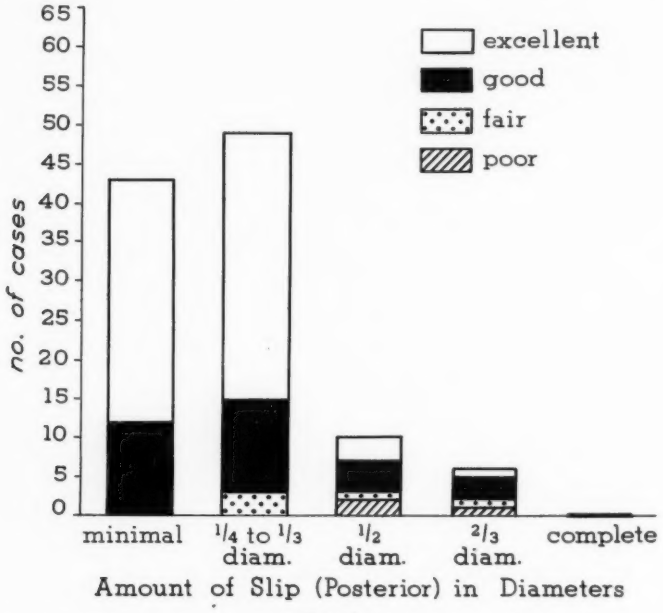


FIG. 6

Results classified by extent of displacement accepted or achieved by closed methods. The only cases not included are those treated by cervical or subtrochanteric osteotomy. If a manipulation was performed the final position is indicated. In a large proportion internal fixation was carried out by a Smith-Petersen nail or Moore's pins. A significant observation is the large percentage of satisfactory results even when a final displacement of one-half or even two-thirds diameter is accepted or obtained. It is doubtful whether so many would be found to be so good when they have reached their fifties.

the principal change is confined to the bony epiphysis and the chance of retaining a useful range of movement is much greater.

Three instances of the former type were seen, two of them in one patient who was kept recumbent on an abduction frame for ten weeks. At the end of this time, both joint spaces were narrow and hip movements were seriously diminished. Subsequent operations on both hips ended in disaster.

Cervical osteotomies were a potent source of avascular necrosis with an incidence of 38·1 per cent. Following closely behind, with 37 per cent, were cases treated by combined manipulation and insertion of a Smith-Petersen nail. Smith-Petersen nailing without previous manipulation carried with it a 5 per cent chance of avascular necrosis.

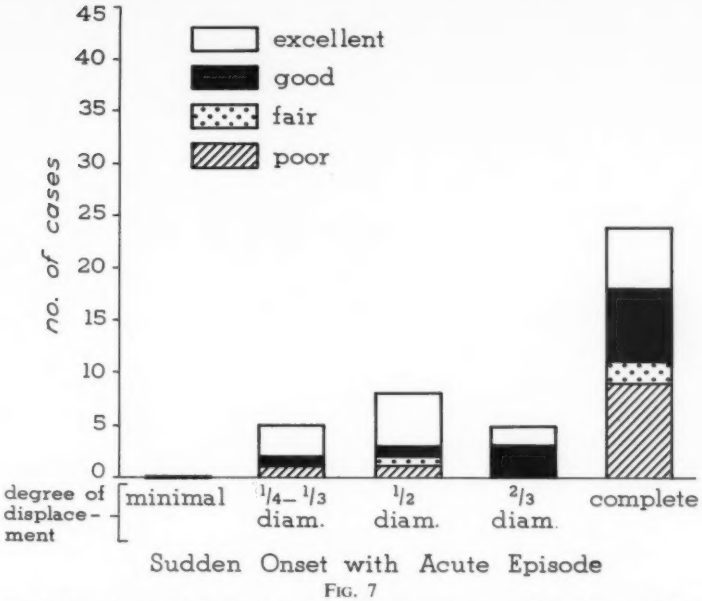


FIG. 7

Results in patients with an acute onset according to the extent of displacement when first seen. Displacement tended to be greater if the onset were acute. The results were unsatisfactory in a large proportion of cases with complete displacement. In this group the results tended to be better in patients seen early and treated by manipulation than in those subjected to cervical osteotomy.

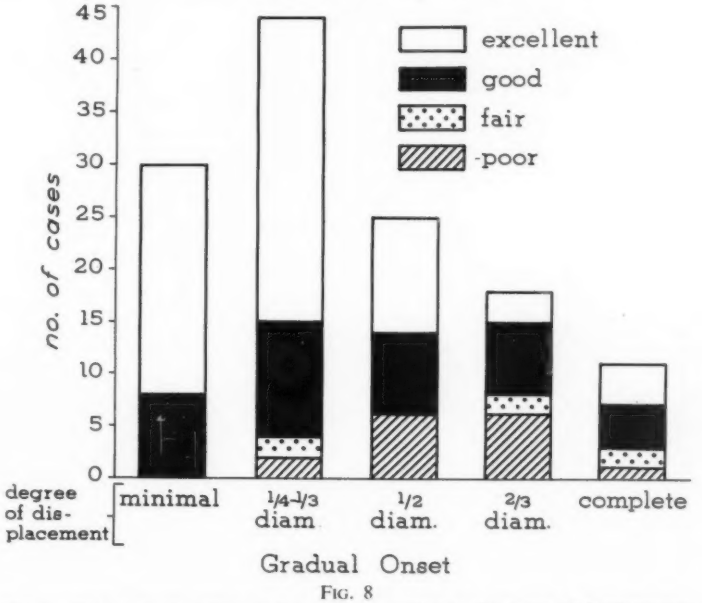


FIG. 8

The results in patients with a gradual onset according to the extent of displacement when first seen. Smaller degrees of displacement were more common with a gradual onset than with a sudden one, and the results were almost uniformly satisfactory. Complete displacements nearly always led to cervical osteotomies, and the results were better than in the group with an acute onset.

Previous mention has been made that no instance of avascular necrosis has been seen after manipulation and the insertion of Moore's pins, but the duration of observation is short. Table VI correlates this complication with the type of treatment.

Final displacement—The extent of displacement that was accepted or finally obtained had some influence on the result. Numerous attempts were made to establish some accurate method of measuring degrees of displacement, but no constant relationships could be found. The method of estimating the amount of slip in relation to the diameter of the head was favoured. This review confirms the usual assertion that a slip of one-quarter or even one-third of the diameter of the head as seen in the lateral view can be accepted. Figure 6 even suggests that about the same result was obtained by accepting a slip of one-half diameter as by performing a cervical osteotomy.

Type of onset—In Figures 7 and 8 an attempt has been made to correlate the type of onset and the initial extent of displacement with the result obtained. A gradual onset was found to be more common than a sudden one, and those with a sudden onset tended to present a greater displacement when first seen. As might be expected, the best results followed a gradual onset and minor slipping.

Delay in treatment was important because it allowed greater slipping and forced the surgeons to employ more hazardous forms of treatment. There was a noticeable trend towards earlier diagnosis in the more recent cases.

SUMMARY AND CONCLUSIONS

1. One hundred and seventy-three hips in 138 patients have been examined and studied in reference to the type of treatment received.
2. Shepherd's method of assessing the results of arthroplasty operations has been adapted to this series.
3. Satisfactory results were found in 77·9 per cent of all patients.
4. The value of straight longitudinal traction is questioned. Medial rotation appears to be an essential step in the reduction of the deformity.
5. Manipulation was found to be a relatively safe and effective method of reducing the deformity in patients seen soon after an acute episode, and should be reserved for them.
6. Complications were common after nailing operations, and included subtrochanteric fracture in three cases.
7. Avascular necrosis was the commonest cause of a poor result. The two types of avascular necrosis are discussed.
8. Avascular necrosis was found in 37 per cent of cases in which a manipulation was followed by a nailing operation.
9. Avascular necrosis was not found in any case in which a manipulation was combined with the use of Moore's pins, but such cases were kept under observation for a shorter time.
10. Avascular necrosis was found in 38·1 per cent of cases of cervical osteotomy.

I would like to thank all of the surgeons who have allowed me to see their patients and who have made my visits to their hospitals so pleasant and instructive.

Particular thanks are due to Mr H. Jackson Burrows and Mr H. J. Seddon, who have made this work possible, and Mr P. H. Newman, Mr E. N. Wardle and Dr W. R. Harris for their helpful advice and encouragement.

I am also grateful for the valuable aid of the staff of the Records Office of the Royal National Orthopaedic Hospital; of Miss M. Bayer, Orthopaedic Secretary; and of Miss Titus of the Medical Art Department of the University of Toronto.

This work was carried out under a grant provided by the Board of Governors of the Royal National Orthopaedic Hospital.

Thirty-four of these patients were examined for Mr P. H. Newman by the writer as an outside assessor and have been reported before by Mr Newman at the meeting of the British Orthopaedic Association in May 1956.

REFERENCES

BADGLEY, C. E., ISAACSON, A. S., WOLGAMOT, J. C., and MILLER, J. W. (1948): Operative Therapy for Slipped Upper Femoral Epiphysis. An End Result Study. Journal of Bone and Joint Surgery, **30–A,** 19.

BLOUNT, W. P. (1945): Discussion following Paper by Green, W. T., on Slipping of the Upper Femoral Epiphysis. Archives of Surgery, **50,** 32.

BURROWS, H. J. (1957): Slipped Upper Femoral Epiphysis. Characteristics of a Hundred Cases. Journal of Bone and Joint Surgery, **39–B,** 641.

CLEVELAND, M., BOSWORTH, D. M., DALY, J. N., and HESS, W. E. (1951): Study of Displaced Capital Femoral Epiphyses. Journal of Bone and Joint Surgery, **33–A,** 955.

COMPERE, C. L. (1950): Correction of Deformity and Prevention of Aseptic Necrosis in Late Cases of Slipped Femoral Epiphysis. Journal of Bone and Joint Surgery, **32–A,** 351.

FOLEY, W. B. (1946): Treatment of Slipped Upper Femoral Epiphysis. Proceedings of the Royal Society of Medicine (Section of Orthopaedics), **39,** 201.

GADE, H. G. (1947): A Contribution to the Surgical Treatment of Osteoarthritis of the Hip-Joint. A Clinical Study. Acta Chirurgica Scandinavica, **95,** Supplementum 120.

GHORMLEY, R. K., and FAIRCHILD, R. D. (1940): The Diagnosis and Treatment of Slipped Epiphyses. Journal of the American Medical Association, **114,** 229.

GREEN, W. T. (1945): Slipping of the Upper Femoral Epiphysis. Diagnostic and Therapeutic Considerations. Archives of Surgery, **50,** 19.

HOWORTH, M. B. (1949): Slipping of the Upper Femoral Epiphysis. Journal of Bone and Joint Surgery, **31–A,** 734.

JERRE, T. (1950): A Study in Slipped Upper Femoral Epiphysis. Acta Orthopaedica Scandinavica, Supplementum 6.

KEY, J. A. (1926): Epiphyseal Coxa Vara or Displacement of the Capital Epiphysis of the Femur in Adolescence. Journal of Bone and Joint Surgery, **8,** 53.

KLEIN, A., JOPLIN, R. J., REIDY, J. A., and HANELIN, J. (1953): Slipped Capital Femoral Epiphysis. Springfield, Illinois: Charles C. Thomas.

KLEINBERG, S., and BUCHMAN, J. (1936): The Operative Versus the Manipulative Treatment of Slipped Femoral Epiphysis with a Description of a Curative Operation. Journal of the American Medical Association, **107,** 1,545.

MARTIN, P. H. (1948): Slipped Epiphysis in the Adolescent Hip. A Reconsideration of Open Reduction. Journal of Bone and Joint Surgery, **30–A,** 9.

MOORE, A. T. (1935): Fracture of the Hip Joint—A New Method of Treatment. International Surgical Digest, **19,** 323.

MOORE, R. D. (1945): Aseptic Necrosis of the Capital Femoral Epiphysis Following Adolescent Epiphyseolysis. Surgery, Gynecology and Obstetrics, **80,** 199.

PERKINS, G. (1932): Treatment of Adolescent Coxa Vara. British Medical Journal, **i,** 55.

RATLIFF, A. H. C. (1956): Pseudocoxalgia. Journal of Bone and Joint Surgery, **38–B,** 498.

SHEPHERD, M. M. (1954): Assessment of Function after Arthroplasty of the Hip. Journal of Bone and Joint Surgery, **36–B,** 354.

VAUGHAN-JACKSON, O. J. (1956): Reducibility of Slipped Femoral Capital Epiphyses. Proceedings of the Royal Society of Medicine (Section of Orthopaedics), **49,** 812.

WALDENSTRÖM, H. (1930): On Necrosis of the Joint Cartilage by Epiphyseolysis Capitis Femoris. Acta Chirurgica Scandinavica, **67,** 936.

WHITMAN, R. (1909): Further Observations on Injuries of the Neck of the Femur in Early Life. Medical Record, **75,** 1.

WILSON, P. D. (1924): Displacement of Upper Epiphysis of Femur Treated by Open Reduction. Journal of the American Medical Association, **83,** 1,749.

WILSON, P. D. (1936): Conclusions Regarding the Treatment of Slipping of the Upper Femoral Epiphysis. Surgical Clinics of North America, **16,** 733.

THE USE OF TIBIALIS POSTERIOR AS A DORSIFLEXOR

D. R. GUNN, SINGAPORE, and B. D. MOLESWORTH, SELANGOR, FEDERATION OF MALAYA

From the Sungei Buloh Leper Settlement, Federation of Malaya

Our interest in tendon transplantation in leprosy was first aroused by the report of Brand (1952), and the possibility of using tibialis posterior as a dorsiflexor was further stimulated by the report of Watkins, Jones, Ryder and Brown (1954), who had used this muscle in poliomyelitis by bringing it through the interosseous membrane. Since we began this series Brand (1956) has stated that he has been using tibialis posterior as a dorsiflexor for some time. The technique that Brand employed is, however, rather different from the one that we have used.

MATERIAL

This report is based upon a study of fifty-six cases, mostly treated at the Buloh Leper Settlement. All except two patients in this series were suffering from leprosy.

Lateral popliteal palsy is one of the commoner effects of leprosy, and for a long time splints have been the only form of treatment. Fortunately, the tibialis posterior muscle is seldom paralysed in this disease.

Selection of cases—The following were the criteria used: 1) complete paralysis of the muscles supplied by the lateral popliteal nerve; 2) a reasonable range of passive dorsiflexion; and 3) an active and powerful tibialis posterior. Age was not considered: the youngest patient was aged ten years, and the oldest was sixty-four.

THE OPERATION

Four incisions are used. Through the first incision, on the medial side of the foot, the tendon of tibialis posterior is freed from its attachment to the tuberosity of the navicular bone and divided just distal to this. Its attachments to the other bones of the foot are cut. Through a second incision just behind the medial malleolus the tendon is hooked up and brought out through the wound. Through the third incision, about six inches long and just lateral to the crest of the tibia, the tibialis anterior is exposed and stripped from the antero-lateral surface of the tibia. The muscle, together with the anterior tibial nerve and artery, is retracted laterally to expose the interosseous membrane. This is incised close to the tibia throughout the length of the incision, and small transverse incisions are made at the upper and lower ends. A probe is passed alongside the tibialis posterior tendon from behind the medial malleolus into the anterior compartment of the leg. Care must be taken to keep the probe close to the lateral margin of the tibia lest it be passed through the fibres of the muscle belly. The tendon is then sutured to the probe, and pulled through gently into the anterior compartment. The tendon is then passed laterally behind the tibialis anterior. This method has been found more satisfactory than trying to pass a blunt hook round the muscle from the anterior incision as suggested by Watkins *et al.*

The point of insertion of the tendon of tibialis posterior into the dorsum of the foot may be varied according to the deformity present, but in the average case experience has shown that the intermediate cuneiform is the most satisfactory site. The area is exposed through a fourth incision, and a tunnel is made through the bone with a gouge.

A " pull-out " wire is inserted into the tendon, and the suture and tendon are drawn subcutaneously into the wound on the dorsum of the foot. The wire is then threaded on to a straight needle and thereby passed through the tunnel in the bone and out on to the sole

of the foot. The foot is fully dorsiflexed, the tendon is pulled well down into the tunnel and secured firmly.

In early cases the wire was tied over a piece of thick rubber tubing, but this was apt to

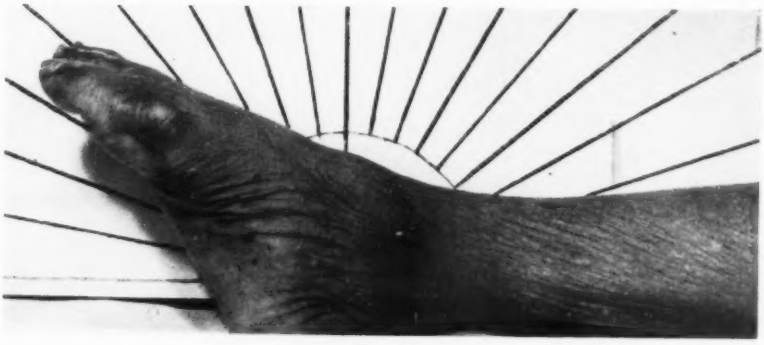


FIG. 1
Case 1—Drop foot before operation.

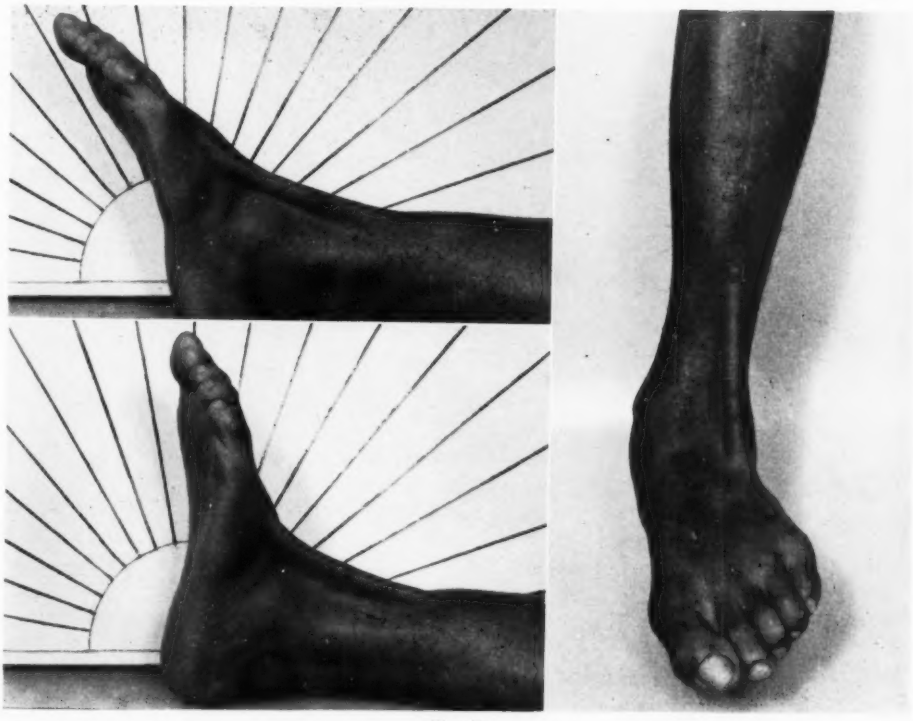


FIG. 2
Case 1—Range of active movement after operation. In this case the tendon was inserted too far laterally, with consequent eversion and bow-stringing.

cause pressure sores, so the method was changed. An oval lead plate pierced with two small holes is moulded to the sole of the foot, and the ends of the wire suture are drawn through the holes and tied firmly over rubber tubing.

A catgut suture is inserted through the tendon and through the periosteum in front of the tunnel through the bone. A well padded plaster is applied and slit.

Post-operative management—The skin sutures are removed after three weeks, and a new plaster is applied. The second plaster is removed seven weeks after operation, and the wire suture is withdrawn. Weight bearing is not allowed for a further two weeks.

Re-education—This is surprisingly easy in most patients. Satisfactory active movement is usually demonstrated on the day that the plaster is removed. Many patients had active control of the transplant when the skin sutures were removed. Some of the less intelligent patients proved more difficult to re-educate, but all ultimately learnt to control the transplanted muscle.

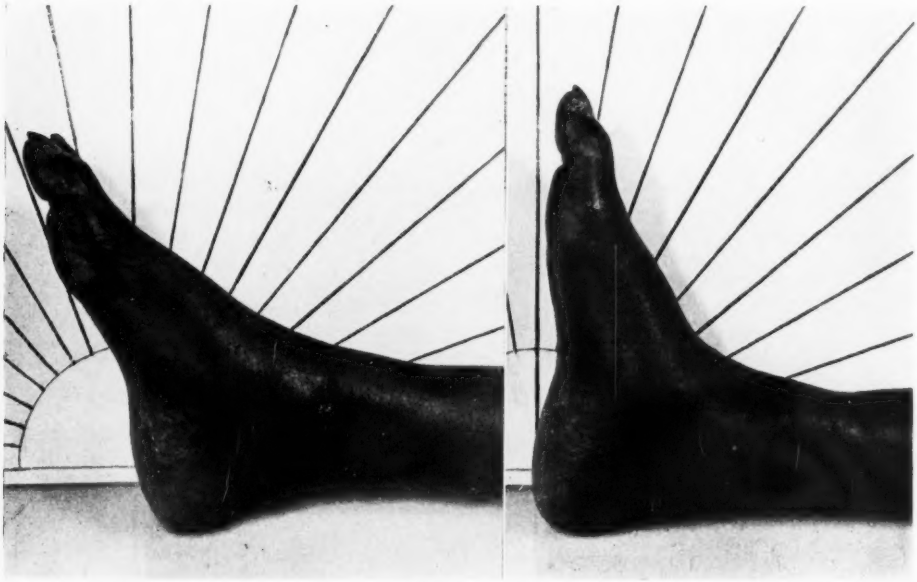


FIG. 3

Case 2—A typical range of active movement after operation in a case of leprosy.

COMPLICATIONS

Infection—There was one case of severe infection in a patient suffering from diabetes and tuberculosis in addition to leprosy, and it was feared that the result would be a failure. Although part of the tendon separated as a slough, however, satisfactory function was finally obtained.

Mild infection occurred in a further six cases, always in the wound on the dorsum of the foot, and it seemed to start about the withdrawal suture which emerged through the wound. In the last twenty cases the withdrawal suture has been brought out through the skin an inch proximal to the wound, and there has been no infection in these cases.

Too lateral insertion of the tendon—In five cases the tendon had been attached too far laterally, and dorsiflexion was accompanied by eversion. In no case was this defect severe enough to worry the patient.

Too medial insertion of the tendon—Marked inversion of the foot occurred only once. In this case the tendon was exposed again and split longitudinally, one half being then sutured to the lateral side of the tarsus. The result is good.

Bow-stringing of the tendon—Four patients showed marked bow-stringing of the tendon. Although this is unsatisfactory from a cosmetic point of view none of the patients wished to

have further treatment for its correction. It should be remembered that the tibialis anterior tendon is normally prominent when the muscle is contracting against resistance.

Pain—In two cases pain persisted for three or four months after operation, but gradually diminished.

Constriction of interosseous space—In one of the early cases the interosseous membrane had been invaded from both sides by new bone, and only an extremely narrow gap remained. A three-inch piece of the fibula was removed to allow the tibialis posterior to be brought forward. The result was satisfactory.

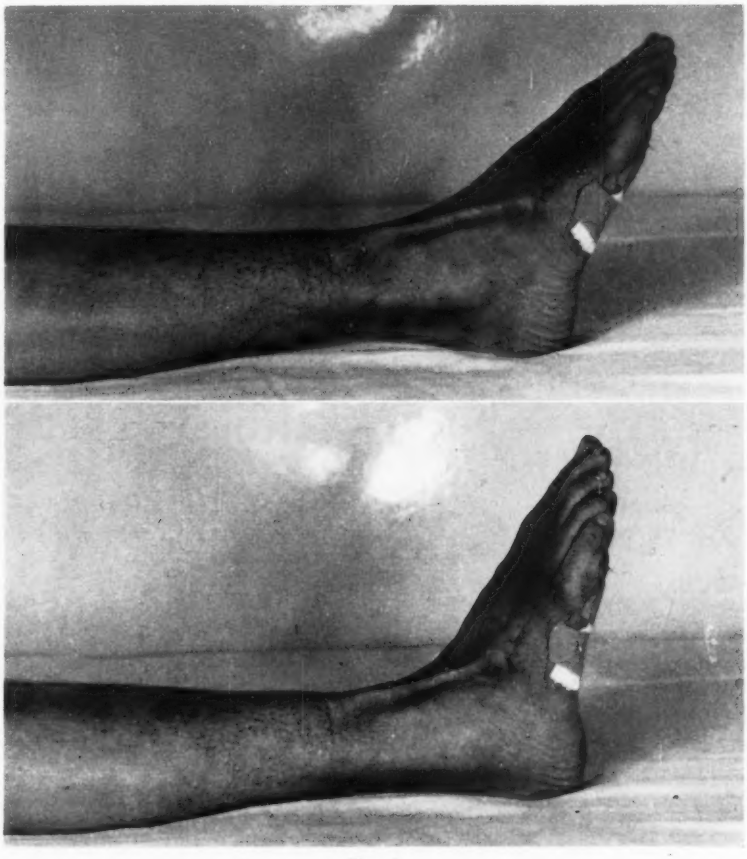


FIG. 4

Case 3—Range of active movement restored in a case of poliomyelitis.

Since then radiographs have been taken before operation to show the width of the interosseous spaces. In one other case the interosseous gap was shown to be narrow; so the tendon was brought round the medial side of the tibia.

Oedema—In the earlier cases walking was allowed immediately after the plaster was removed, seven weeks after operation, and persistent oedema proved troublesome on several occasions. Later, the patients were not allowed to walk until two weeks after the plaster had been removed, and this complication was eliminated.

Pyogenic arthritis—One patient developed staphylococcal arthritis of the ankle some weeks after operation, and after he had been walking well.

TABLE I

RESULTS IN FIFTY-SIX CASES

Satisfactory . . .	49
Slightly improved . .	3
Failed	1
Death from another cause	1
Unknown . . .	2

RESULTS

A satisfactory result is considered to have been gained when the transplanted tendon functions actively with a sufficient range of controlled movement to allow the patient to walk well. It is not suggested that these patients have a normal range of dorsiflexion and plantar-flexion. The results are shown in Table I. Illustrative cases are shown in Figures 1 to 4.

DISCUSSION

It was hoped that this operation would achieve two things: a greatly improved gait, and a reduction in the high incidence of ulceration along the outer side of the foot that is seen in patients with lateral popliteal palsy from leprosy.

We believe that the first objective has been obtained in most cases.

So far, there has been no recurrence of ulceration in patients with a satisfactory transplant, because they no longer walk on the outer side of the foot. The time that has elapsed is short, and a further review after a much longer interval will be necessary.

Although this series includes only two cases of drop foot from poliomyelitis, the results are so satisfactory that we feel that this operation should be considered in the cases that do show a suitable pattern of paralysis.

SUMMARY

1. Fifty-six cases of tibialis posterior transplant for drop foot are reported.
2. The results are known to be satisfactory in forty-nine of the fifty-six cases.
3. Serious complications have been few.
4. Re-education has been easy in the great majority of cases.

REFERENCES

BRAND, P. W. (1956): Treatment of Leprosy. II. The Role of Surgery. New England Journal of Medicine, **254**, 64.

BRAND, P. W. (1952): The Reconstruction of the Hand in Leprosy. Annals of the Royal College of Surgeons of England, **11**, 350.

WATKINS, M. B., JONES, J. B., RYDER, C. T., Jun., and BROWN, T. H., Jun. (1954): Transplantation of the Posterior Tibial Tendon. Journal of Bone and Joint Surgery, **36-A**, 1,181.

MARCH GANGRENE

Ischaemic Myositis of the Leg Muscles from Exercise

JOHN P. BLANDY, LONDON, ENGLAND, and ROBERT FULLER, GLASGOW, SCOTLAND

From the Surgical Division and Convalescent Wing, Cowglen Military Hospital, Glasgow

Ischaemic necrosis of certain muscles of the leg, developing apparently spontaneously after exercise, was first described independently by Vogt (Horn 1945), and by Severin, in 1943. It occurred in fit young soldiers undergoing training. The next detailed description of a case was given by Sirbu, Murphy and White (1944) who wrote: " On the assumption that it was due to the cumulative effect of multiple microtraumata rather than to a single injury it simulated a march fracture and could be called march myositis. This is, in a sense, a misnomer, since the pathology was not that of inflammation of muscle but of infarction."

Sixteen cases have been described in some detail and these are summarised in Table I. Other cases of which we have incomplete information were mentioned by Horn (1945) and Hughes (1948). We are able to add three new cases of our own, and have knowledge of two others.

The condition is characteristic, and, if it is borne in mind, easily recognised. It occurs in healthy young men and follows physical activity of one sort or another; for example, football, marching or drill. There is no history of injury. The onset is gradual, the condition developing over a period of some hours after the cessation of the activity. There is increasingly severe pain which usually awakens the patient some time after he has gone to bed. The affected part becomes swollen and tender, and the overlying skin becomes red and hot. The patient is unable to move the foot: any attempt at passive movement causes intense pain. If the condition remains untreated, the pain, tenderness, redness and swelling gradually subside over the course of several days. The affected muscles are then felt to be woody hard. There may be some contracture. Voluntary movement is completely absent. The affected muscles are unresponsive to any stimulus, and they are electrically silent. In addition there may be evidence of a peripheral nerve lesion, with some anaesthesia and a lower motor neurone paralysis of muscles other than those directly involved in the ischaemia.

CASE REPORTS

The three cases which we describe illustrate the condition well, and since so few descriptions have appeared we feel justified in reporting them in some detail.

It has been stated that the peroneal muscles are never involved (Carter, Richards and Zachary 1949). That this is not so is clearly shown in Cases 2 and 3 in which the peroneal muscles alone were involved in the ischaemia. It is further of interest to note that in Case 2 the peroneal muscles of both legs were affected at separate times but under identical circumstances.

Case 1—Private soldier, aged twenty-three, who had been a coal-miner and football player for eight years before enlisting. After six weeks in the Army he played the first game of football of the season. During the game he received at least one " glancing tap " from a canvas plimsoll over the shins.

Eight hours after the game, while he was in bed, a sudden shooting pain began in the right anterior tibial region. Intermittent at first, the pain later became constant, preventing sleep, and he was unable to move his foot.

Two hours after the onset the pain was so bad that he sent for the medical officer. The antero-lateral aspect of the leg was then red, warm, swollen and tender. Two small pea-shaped

swellings were visible at about the junction of the middle and lowest thirds of the leg. Radiographs showed no abnormality. It was thought that he had thrombophlebitis and he was treated with bed rest, analgesics and local heat. The pain continued, and for the next three nights disturbed his sleep.

TABLE I

PREVIOUS REPORTS OF TRUE MARCH GANGRENE

Age	Occupation	Onset	Side	Muscles affected*	Author	Date
25	Conscript	Walking match	Left	T.A., E.H.L.	Severin	1943
38	Soldier	Long march	Both	T.A.	Sirbu, Murphy and White (Case 8)	1944
23	Soldier	20-mile march	Right	T.A., E.H.L., E.D.L., Per.	Horn (Case 1)	1945
26	Soldier	Walking	Right	T.A., E.H.L.	Horn (Case 2)	1945
25	Air Force cadet	Night flying and half-mile walk	Right	T.A., E.H.L., E.D.L.	Phalen (Case 1)	1948
24	Greek emigré	Broad jumping contest on concrete	Both	T.A., E.H.L., E.D.L.	Pearson, Adams and Denny-Brown	1948
23	Sergeant	Football	Right	T.A., E.H.L., E.D.L.	Hughes (Case 1)	1948
20	Leading aircraftman	Football	Right	T.A.	Hughes (Case 2)	1948
20	Signalman	Football	Right	T.A., E.H.L., E.D.B.	Carter, Richards and Zachary (Case 1)	1949
18	Serviceman	Marching	Left	T.A., E.H.L., E.D.L., E.D.B.	Carter *et al.* (Case 2)	1949
20	Civilian	Football	Right	T.A., E.H.L., E.D.L.	Carter *et al.* (Case 3)	1949
29	Serviceman	Football	Right	T.A., E.H.L., E.D.L., E.D.B.	Carter *et al.* (Case 4)	1949
40	Serviceman	Football	Right	T.A., E.H.L., E.D.B.	Carter *et al.* (Case 5)	1949
29	Serviceman	Football	Right	——, E.H.L., E.D.L.	Carter *et al* (Case 6)	1949
21	Serviceman	Football. Onset of pain at night	Left	T.A., E.H.L., E.D.L., E.D.B.	Carter *et al* (Case 9)	1949
25	Hiker: civilian	First walk of the season	Right	T.A.	Tillotson and Coventry	1950
21	Soldier	Walking on paved street	Right	T.A., E.H.L., E.D.L.	Campbell and Van Wagoner (Case 1)	1955
35	Soldier	3½ hours' marching	Right	T.A., E.H.L., E.D.L.	Campbell and Van Wagoner (Case 2)	1955
30	Soldier	3 months after high ligation and stripping of varicose veins, three days after return to duty	Right	T.A., E.H.L., E.D.L.	Campbell and Van Wagoner (Case 3)	1955

* T.A. = Tibialis anterior E.D.L. = Extensor digitorum longus E.H.L. = Extensor hallucis longus
E.D.B. = Extensor digitorum brevis Per. = Peroneal muscles

Nine days after the onset of pain he was transferred to this hospital where examination revealed that the anterior tibial compartment was swollen and tender, and felt woody. The overlying skin was red. Voluntary movement was present in the peroneal muscles, but there was complete absence of voluntary extension of the toes and of dorsiflexion of the foot (Fig. 1).

Passive dorsiflexion and plantarflexion were intensely painful and limited to a few degrees. There was loss of sensation to pinprick in the first interdigital cleft. Pulsation was felt in the dorsalis pedis artery. There was no response to galvanism in the tibialis anterior, extensor digitorum longus, or extensor hallucis longus; but a response was obtained in extensor digitorum brevis and in the peroneal muscles. (A full test was not carried out because of the pain.) Full general examination showed no other abnormal physical signs.

At the time of his admission the condition was already nine days old, but the risk of opening the muscle compartment was balanced against the certain complete loss of function if it were left.

Operation—Under general anaesthesia a longitudinal incision was made over the right anterior tibial muscles. The skin was oedematous. The superficial fascia was of normal colour and its veins were normal. On slitting it open the deep fascia gaped for three-quarters of an inch (Fig. 2). The underlying muscle was woody hard. It varied in colour from brown on the surface to pale yellowish-grey at a depth of one centimetre. In taking material for histological examination a small arteriole was cut across and bled briskly, until controlled by warm packs. The skin was approximated, gaps being left because of the swelling. Prophylactic penicillin and streptomycin were given for four days.

FIG. 1

Case 1—Photograph immediately before operation. The patient was attempting to dorsiflex both feet: the impairment of active movement on the right side is obvious. There was slight discoloration and fullness over the right anterior tibial muscles.

Post-operative course—The next morning the patient was free from pain, and in general felt

FIG. 2

Case 1—Photograph taken at operation. After incision the deep fascia gaped for about three-quarters of an inch, as may be seen. The incision in the fascia was prolonged distal to the limit of the skin incision.

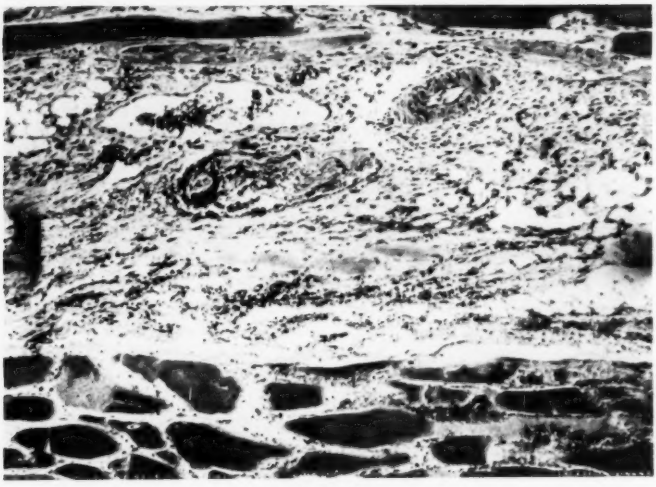


FIG. 3

Case 1—Section of specimen from right tibialis anterior nine days after onset of march gangrene. Dead muscle fibres at the bottom; the nuclei have disappeared and the striation is blurred. Migrant polymorphonuclear leucocytes are seen in the swollen and granular fibrous tissue between the dead fibres; and there are activated fibrous granulation tissue and macrophages around the artery and nerve. (Haematoxylin and eosin, ×65.)

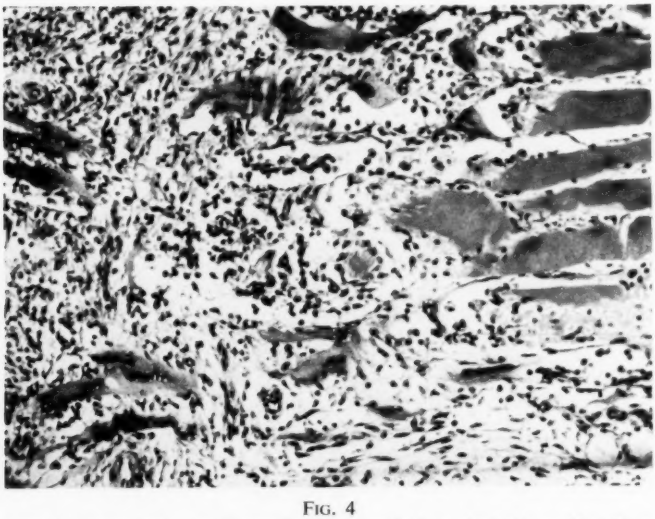


FIG. 4

Case 1—Same section as Figure 3. Adjacent field to show the multinucleate syncytial masses representing attempts at regeneration by the muscle fibres in relation to vascular granulation tissue. (×120.)

much relieved. The skin wound healed cleanly. On the fourteenth day after operation sensation began to return in the first interdigital cleft. Full function eventually returned to the extensor digitorum longus, the extensor hallucis longus and the extensor digitorum brevis. Some voluntary contraction returned and could be felt in the belly of the tibialis anterior, but its function remained limited, apparently by fibrosis in its middle third.

Histological examination of the specimen showed a fragment of necrotic muscle, with regenerating fibres and early organisation by granulation tissue where the blood vessels entered from the fascia (Figs. 3 and 4).

Case 2—Recruit, aged twenty-eight. A slater before enlistment, he occasionally used to get cramps in the calves while climbing ladders, but never in the peroneal muscles.

On the evening of his seventh day of drill (spent largely in practising " turning by numbers") he was awakened by a severe sharp unremitting pain in the peroneal aspect of his left leg. In spite of rest the pain became steadily worse, and on the third day the appearance of redness and tenderness over the area led to a diagnosis of thrombophlebitis, and he was treated by rest in bed, penicillin and local heat.

The pain continued for a further two days, and the local tenderness for a week. When this subsided he was left with a total loss of function of the peroneal muscles; the other muscles were clinically normal. He was further treated by a graduated programme of exercise and activity. After four months he had sufficiently compensated for his loss of peroneal function to be returned to his unit.

After only five days of drill, on four of which he again practised " turning by numbers," he experienced increasing stiffness in the same part of the other leg. This became increasingly painful in bed that night, preventing sleep. On the following day he was admitted to this hospital.

On admission he was a stocky fit young man with a tense tender swelling on the antero-lateral aspect of his right leg. Passive inversion of the foot was intensely painful. There was no sensory loss. The dorsalis pedis and posterior tibial pulsations were felt.

Operation—Under general anaesthesia a longitudinal incision was made and both the anterior tibial and peroneal compartments were exposed and incised. The peroneal compartment was woody hard. As soon as it was incised the fascia gaped for one and a half inches, allowing greyish-brown muscle, under obvious tension, to bulge out. The tibialis anterior was of normal tone, tension and colour. The skin was approximated, gaps being left because of the swelling of the calf. The leg was kept elevated for four hours. Prophylactic penicillin was given for two days.

Progress—The next morning the patient was free from pain, and was able to move his toes without discomfort. The wound healed uneventfully. Voluntary contraction was palpable in the belly of the peroneus longus on the tenth day after operation. By the third week normal function had returned to this leg. Normal strength-duration curves were obtained: this was in marked contrast to the other leg, in which no reaction could be obtained in the peroneal muscles.

Electromyography was later performed: when needle electrodes were inserted into the left peroneus longus no potentials were seen. The findings were consistent with necrosis of muscle. In the right peroneus longus, discrete normal potentials were observed on activity and there was some fibrillation at rest. This indicated a partial lower motor neurone lesion of the right peroneus longus.

The Wassermann and Kahn tests were negative. The urine was normal and the blood pressure persistently normal.

Histological examination—Specimens were taken from the peroneus longus muscle of each leg under local anaesthesia four weeks after the operation. The specimen from the *right* leg showed scarring between the muscle fibres, variable and irregular in amount. The muscle fibres varied greatly, probably about half being completely absent; the survivors were often

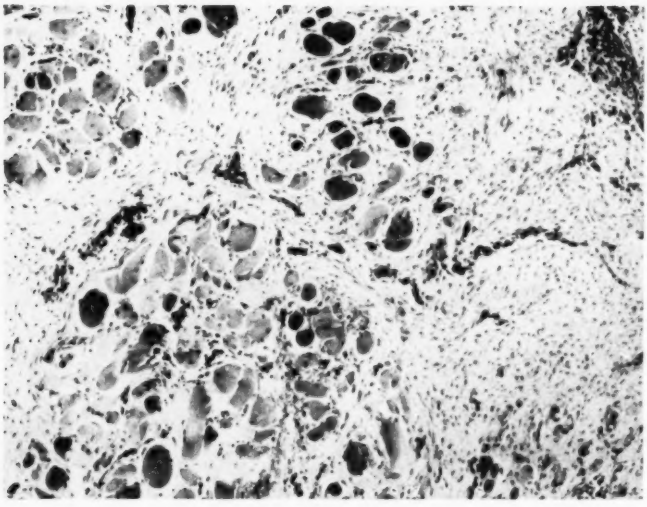


FIG. 5

Case 2—Section from right peroneus longus four weeks after onset of march gangrene which was relieved by decompression thirty-six hours after the onset. Scar tissue mingled with surviving muscle fibres of varying size and staining reaction. (Haematoxylin and eosin, ×71.)

FIG. 6

Case 2—Section from left peroneus longus six months after onset. The muscle was not decompressed. Incomplete death *in situ* of muscle fibres with little reaction or regeneration. (Haematoxylin and eosin, ×135.)

much larger than normal and the depth of staining varied from as deeply eosinophil as normal to as pale as fibrous tissue. Some fibres were very pale and small, and had seemingly only just survived. There were still a few inflammatory cells among the fibres, mainly macrophages; no polymorphs were seen (Fig. 5).

The specimen from the *left* peroneus longus, taken six months after the onset of symptoms, showed nearly normal appearances in some areas; in others the sections showed dead muscle fibres with longitudinal separation of their fibrillae, disappearance of their nuclei, and relatively few inflammatory cells (Fig. 6). There was no evidence of regeneration.

Case 3—Private soldier aged twenty-two. This patient was a coal-miner before enlistment, and had thirteen months' service. He recalled that while playing football he received a kick on the right leg. He said that this was not severe and did not worry him or cause him to stop playing. Some time after the game he began to develop pain and swelling and a " blotchy redness " over the lateral aspect of the right leg. After he went to bed the pain became increasingly severe and prevented sleep. Because of the pain he was unable to move the foot. A radiograph showed no abnormality. He was treated with penicillin and analgesics. Over the next four days the pain and swelling subsided, and, as this happened, he became aware that he was unable to move his toes or pull his foot up.

Three weeks after the onset he was transferred to this hospital with a diagnosis of lateral popliteal nerve palsy. Examination at this time showed him to be stocky and rather bow-legged. He was free from pain and tenderness. There was loss of sensation over the lowest third of the right leg and in the first interdigital cleft. The anterior tibial muscles felt soft and of normal consistency, but the whole of the peroneal compartment was hard and woody. No voluntary movement could be detected in either group of muscles, or in the extensor digitorum brevis. There was no restriction of passive dorsiflexion or plantarflexion, but quite a definite sense of resistance to passive inversion.

Strength-duration curves showed complete denervation in the right tibialis anterior: no response could be obtained from the right peroneal muscles.

A flicker of voluntary movement of the toes appeared one month later and at six weeks (nine weeks from the onset) strength-duration curves showed some re-innervation in the tibialis anterior and extensor digitorum longus. A little voluntary movement in these muscles appeared. The peroneal muscles remained inert and unresponsive. There was some further gain in power, but five months after the onset re-innervation of the anterior tibial muscles was still incomplete, and a toe spring was necessary. No recovery had taken place in the peroneal group, from which a biopsy specimen was taken under local anaesthesia.

Histological examination of a specimen of the peroneal muscles, taken five weeks after the onset of symptoms, showed almost normal muscle tissue. Either a piece of the wrong muscle was taken at the operation—we believe this is unlikely—or the fragment was taken from a part of the muscle that was relatively unaffected by the ischaemic process. This has been encountered before (Pearson, Adams and Denny-Brown 1948).

DISCUSSION

Etiology—Ischaemic necrosis of muscle is rare (Griffiths 1951), and the muscles of the lower limbs are less frequently affected than those of the upper limbs (Thomson and Mahoney 1951). In the lower limb the muscles of the anterior tibial compartment seem to be particularly susceptible to ischaemia. When they are affected there is usually an accompanying lesion of the anterior tibial nerve in its course through the myofascial compartment, with consequent paralysis of the extensor digitorum brevis (which is not contained in the anterior tibial compartment, and escapes direct ischaemic damage) and anaesthesia in the first interdigital cleft.

Together, this triad, when it occurs in fit young soldiers after exercise or injury, has been

TABLE II

ISCHAEMIC NECROSIS OF THE ANTERIOR TIBIAL MUSCLES FROM OTHER CAUSES

Age	Occupation	Onset	Side	Muscles affected*	Author	Date
1. VASCULAR COMPLICATIONS OF FRACTURES. (A further fourteen cases complicating fracture, thirteen of which required amputation, were described by Child 1942)						
29	Officer	Run over; fractured tibia and fibula involving knee. " Cellulitis " in anterior tibial on 22nd day	—	Anterior crural muscles	Sirbu, Murphy and White (Case 5)	1944
23	Soldier	Compound fracture of tibia and fibula. No initial circulatory impairment	—	T.A.	Sirbu *et al.* (Case 6)	1944
33	Red Cross worker	Compound fracture tibia and fibula. Both legs. Plaster	Both	T.A., E.H.L., E.D.L.	Phalen (Case 2)	1948
21	Sergeant	Mortar wound. Chip fracture tibia. Plaster for 3 days	Right	T.A., E.H.L., E.D.L.	Phalen (Case 3)	1948
21	—	Fractured tibia and fibula, gross swelling. Plaster 9 days and skeletal traction	—	E.H.L., also F.H.L. and E.D.B.	Bowden and Gutmann (Case 15)	1949
23	—	Compound fracture left tibia and fibula	Left	T.A., E.H.L., E.D.L., Per.	Child	1942
2. VASCULAR ACCIDENTS AND DISEASE						
19	Leading aircraftman	? Periarteritis nodosa: ? Rheumatism	—	T.A., E.H.L.	Hughes (Case 3)	1948
31	Truck driver	Blow behind knee, rupture of popliteal artery	Right	T.A.	Horn and Sevitt	1951
51	Woman	Auricular fibrillation, embolus	Right	T.A.	Watson	1955
70	Woman	Auricular fibrillation and embolus	Left	T.A.	Watson	1955
Middle aged	Man	Cardiac infarct. Embolus	—	T.A.	Tait	1955
70	Woman	Stroke. Fell. Developed ulcer exposing tibia on right side. Many advanced neurovascular degenerative diseases. Thrombosis of anterior tibial vessels	Right	T.A., E.H.L., E.D.L.	Moretz (Case 1)	1953
47	Man	Endarteritis obliterans. Sudden onset pain, pallor, skin discoloration over anterior tibial compartment; reversed by treatment—intravenous papaverine, sympathectomy	Right	Anterior tibial muscles	Moretz (Case 2)	1953
49	Man	Gangrene of skin and muscle after thrombosis anterior tibial artery; peripheral vascular disease	—	T.A., E.H.L., E.D.L.	Moretz (Case 3)	1953
37	Man	Rheumatic heart disease; embolism. Embolectomy followed by syndrome, relieved by prompt fasciotomy with nearly full recovery	Right	Muscles of anterior tibial compartment	Moretz (Case 4)	1953
—	Young infantryman	Penetrating shell wound of leg involving anterior tibial artery	Right	T.A., E.H.L., E.D.L.	Edwards (Case 3)	1953
3. MISPLACED BLOOD TRANSFUSION						
23	Serviceman	Blood transfusion into leg for severe shock; gunshot wounds elsewhere	Right	T.A., E.H.L., E.D.L.	Carter *et al.* (Case 7)	1949
29	Sergeant	Many gunshot wounds transfused one pint into long saphenous vein	Right	T.A., E.H.L., E.D.L.	Carter *et al.* (Case 8)	1949

* T.A. = Tibialis anterior E.D.L. = Extensor digitorum longus E.H.L. = Extensor hallucis longus
E.D.B. = Extensor digitorum brevis Per. = Peroneal muscles F.H.L. = Flexor hallucis longus

TABLE II—*contd.*

Age	Occupation	Onset	Side	Muscles affected*	Author	Date
4. OTHERS						
—	Soldier	Twisted ankle. Strapped	—	T.A.	Psaki and Schields	1952
—	Young soldier	Small muscle hernia repaired under local anaesthetic. Signs of inflammation on 5th day	—	Anterior crural muscles	Sirbu, Murphy and White (Case 7)	1944

* T.A.=Tibialis anterior

called the anterior tibial syndrome (Carter, Richards and Zachary 1949), a useful term which has, unfortunately, been extended to cases of quite different origin (Watson 1955, Tait 1955, Moretz 1953).

When an overt vascular lesion precedes ischaemia of muscle, we are not dealing with any newly recognised phenomenon (*cf.* Albucasis, and the Unfortunate Eunuch, cited by Bell 1826). Recorded cases of this sort affecting the anterior tibial muscles are collected and summarised in Table II. They are quite distinct etiologically from the condition under discussion, which occurs in fit young soldiers, is unrelated to vascular disease or to injury, and is not confined to the anterior tibial muscles. We suggest, following Sirbu, Murphy and White (1944), that "march gangrene"† is a more precise, more accurate, and more convenient description. (The triad of necrosis of the anterior tibial muscles, with paralysis of extensor digitorum brevis and anaesthesia of the first interdigital cleft may correctly continue to be regarded as a syndrome, one cause of which is march gangrene.)

Histology—It might be expected that a study of the morbid histology would throw light on the pathological process that leads to the development of march gangrene. This is not so. Even in the more common ischaemic contracture of Volkmann the exact pathological process is as uncertain as the interpretation of the histology. Volkmann at first attributed the condition to venous obstruction, but later changed his opinion, and favoured arterial occlusion (Volkmann 1881).

Griffiths (1940) argued that arterial occlusion was the commonest, if not the sole, factor, though the work of Brooks (1922, 1924) and Middleton (1930) had shown that venous obstruction alone could produce ischaemic contracture. Much of the argument rests on the interpretation of the histology of muscle, which is notoriously difficult (Adams, Denny-Brown and Pearson 1953).

Experimentally, if there is pure arterial obstruction without oedema or venous congestion, the muscle fibres die *in situ*, their nuclei becoming pyknotic, their striations exaggerated and their fibrils segmented: a muscle sequestrum is formed (Harman and Gwinn 1949). If there is oedema or venous congestion then cellular infiltration breaks up the orderly arrangement of the muscle fibres, and they become more or less completely destroyed by the phagocytosis, being replaced by fibrous tissue (Brooks 1924, Middleton 1930).

In their painstaking study of the histology in sixteen cases of ischaemic contracture, from a variety of causes, Bowden and Gutmann (1949) separated three types of lesion in muscle: 1) Massive necrosis of muscle fibres, the necrotic areas being surrounded by a sharply defined zone of fibrous tissue; 2) dense interstitial fibrosis; and 3) elements of both these types; scattered foci of necrosis together with interstitial fibrosis.

† Authors have generally distinguished mortification into two stages; the first or incipient one they name *gangrene*; the second or latter stage, that is, when the part has become quite cold, black, fibrous, incapable of moving, and destitute of all feeling, circulation and life, is termed *sphacelus* (Castle 1831).

In the first group there had probably been serious damage to the main artery of the limb or to the vessel supplying the affected muscles, but in the second and third groups the causes were more varied. It is evident that the clinical features do not often match the histological picture because in practice pure arterial or venous occlusion seldom occurs. It is therefore

TABLE III

HISTOLOGY IN RECORDED CASES OF MARCH GANGRENE

Time from onset to biopsy	Histology	Reference
3 days	Interfibrillary oedema; loss of striations; fragmented pieces; round cells and macrophages; capillary dilation	Horn (1945) (Case 2)
4 days	Necrosis of striated muscle	Sirbu, Murphy and White (1944) (Case 8)
6 days	Patchy loss of staining; disking; interstitial fibrosis; scattered haemorrhages	Horn (1945) (Case 1)
17 days	In some pieces, normal muscle; in others, marked fibrous tissue replacement; muscle fibres in all stages of degeneration; the necrotic fasciculi bordered by areas of regenerative activity	Pearson, Adams and Denny-Brown (1948)
20 days	Ischaemic necrosis	Campbell and Van Wagoner (1955) (Case 3)
20 days	Necrotic muscle tissue; new fibrous tissue formation	Carter, Richards and Zachary (1949) (Case 2)
28 days	Gross changes typical of ischaemic necrosis	Hughes (1948) (Case 1)
5 weeks	Complete loss of differential staining. Interstitial tissue oedematous; masses of necrotic debris. A medium calibre vascular channel occluded by thrombus	Campbell and Van Wagoner (1955) (Case 1)
8 weeks	Infarcted muscle, organisation and granulation tissue at periphery	Carter, Richards and Zachary (1949) (Case 1)
8 weeks	Histology only available after infection had been present for two months. Not relevant	Phalen (1948) (Case 1)
10 weeks	Ischaemic fibrosis, peripheral fibrous tissue replacement	Carter, Richards and Zachary (1949) (Case 9)
3 months	No necrosis, patchy muscle fibres in dense fibrosis	Carter *et al.* (Case 4)
3 months	Infarcted muscle, fresh patchy haemorrhages	Carter *et al.* (Case 6)
4 months	Necrosis, fibrosis, haemorrhages	Carter *et al.* (Case 5)
4 months	Mass necrosis, surrounded by dense cellular fibrous tissue	Hughes (1948) (Case 2)
24 weeks	Fibrous tissue, inflammation, necrosis	Tillotson and Coventry (1950)
15 months	Muscle tissue interwoven by network of cellular connective tissue; individual muscle bundles showed necrotic changes	Severin (1943)

impossible to deduce the cause of the ischaemia from the histological appearance. In fact the histological changes in the documented cases of march gangrene show a considerable variation, not only from case to case (Table III), but also in different parts of the same muscle (as in Case 1 above); in one place the muscle may be normal, whereas a nearby portion shows advanced degeneration (Pearson, Adams and Denny-Brown 1948).

Pathological process—Several mechanisms in the production of march gangrene have been suggested. Vogt (Horn 1945) suggested that the margin of the interosseous membrane might damage the anterior tibial artery, but dissection has shown that the vessels lie one to two centimetres away from the membrane (Hughes 1948). Horn (1945), finding evidence of endarteritis in his specimen, suggested that the anterior tibial artery was the seat of inflammation. These changes, however, are more readily interpreted as the result rather than the cause of the muscular atrophy.

It is known that during exercise a muscle may gain as much as 20 per cent of its own weight, and swell accordingly, from an accumulation of extracellular tissue fluid (Wright 1952). If the pressure of the fluid increases, even to a level well below the systemic arterial pressure, it is capable of producing muscular ischaemia (Lewis 1936).

Unaccustomed exercise is usually followed by stiffness which may be painful. This commonly affects the anterior tibial muscles, earning the title " shin-splints " amongst American college athletes. (It is equally well known, we are told, among the young ladies of a teachers' training college in this country, under the more appealing name of "fresher's leg.") This stiffness normally wears off.

There appears to be a critical point beyond which irreversible damage occurs in the muscle. Usually this critical point is never passed, but among competitive " body-builders," who have developed highly specialised techniques for causing muscular hypertrophy, it is well recognised that if " muscle-cramping " exercises are carried beyond a certain point, flushing, oedema and vesication of the skin over the muscles occur. The muscles then become intensely painful, and unless immediately stretched, become permanently shortened—a condition known as " muscle-binding " (MacQueen 1954). Such cutaneous flushing, oedema and vesication is also characteristic of Volkmann's ischaemic contracture (Thomson and Mahoney 1951).

One peculiar feature of march gangrene is that its onset is delayed until the patient ceases the activity and goes to bed. It seems possible that the diminution of blood flow to muscle which occurs at rest, together with the decreased drainage due to cessation of the mechanical pumping of the contracting muscle, might precipitate ischaemia in a myofascial compartment which is already over-distended with tissue fluid.

Hughes (*loc. cit.*) considered a similar explanation but rejected it because it did not explain the supposed immunity of the peroneal muscles. He studied the arterial blood supply and the intramuscular anastomosis in the anterior tibial group of muscles, and found them to be poor when compared with the richly vascular peroneal group (Hughes (*loc. cit.*), Blomfield 1945, LeGros Clark and Blomfield 1945). He attributed the ischaemia to a segmental spasm of the anterior tibial artery. In support of this the biopsy material from his cases showed an arterial type of infarction. But infarction of the peroneal group of muscles may occur, and without involvement of other muscles (Cases 2 and 3). Since this group has a good intramuscular anastomosis, derived from several sources, only a segmental spasm of a major artery could cause infarction, and this would necessarily lead to ischaemia in the anterior tibial group (Edwards 1953).

Nearly always the condition follows unaccustomed or unusually severe exercise (Carter, Richards and Zachary 1949), and it has been suggested (Sirbu, Murphy and White 1944) that " multiple microtraumata " within the muscle would aggravate the exercise oedema, or that gross rupture of muscle might take place (Pearson, Adams and Denny-Brown 1948) with local haemorrhage into the compartment. In some sections small haemorrhages have in fact been noted, but these may have been due to the taking of the specimen. When so many of the patients were playing football before the condition arose, one clearly cannot ignore the possible effects of local knocks or blows. It is quite another matter to gauge their significance when we have seen that the gangrene can follow marching, hiking or foot-drill.

If, in addition to the accumulation of tissue fluid under pressure within the semi-rigid fascial compartments of the leg, there were also some thrombosis in the intramuscular arterioles

TABLE IV

TREATMENT OF MARCH GANGRENE IN PREVIOUSLY RECORDED CASES

Treatment	Result	Reference
Rest in bed for 6 days. Explored at 15 months	Incomplete foot drop because of contracture	Severin (1943)
Incision through fascia on fourth day	Left side—gangrene excised. Right side—recovered except for superficial patch of gangrene	Sirbu, Murphy and White (1944) (Case 8)
Sympathetic block with temporary benefit. Repeated, no good. Then fasciotomy on third day	Entire tibialis anterior and extensor hallucis longus removed by finger dissection on sixteenth day, when infected	Horn (1945) (Case 2)
Incision through fascia on sixth day	Seemed to regain circulation; incision could not be closed; graft; no recovery of extensors or peronei	Horn (1945) (Case 1)
Diagnosed as osteomyelitis. 4-inch incision. Tibia drilled on second day	Two months later, sinus; all extensors removed by finger dissection	Phalen (1948) (Case 1)
Bed rest, penicillin from third day. Biopsy seventeenth day	No recovery	Pearson, Adams and Denny-Brown (1948)
Splint	Contracture maximal in tibialis anterior, present to much less degree in extensor hallucis longus and extensor digitorum longus	Hughes (1948) (Case 1)
Penicillin, sulphapyridine, faradism, radiant heat, massage	Contracture in tibialis anterior and extensor hallucis longus	Hughes (1948) (Case 2)
No details	Recovery from lower motor neurone lesion at 14/52. Contracture in tibialis anterior, and extensor hallucis longus, but extensor digitorum longus and extensor digitorum brevis returned to normal	Carter, Richards and Zachary (1949) (Case 1)
No details	Lower motor neurone lesion recovered at 12/52. Foot drop required apparatus	Carter *et al.* (1949) (Case 2)
No details	Not followed up	Carter *et al.*(1949) (Case 3)
" Abscess " incised	Some recovery in tibialis anterior and extensor digitorum longus, at 6/12	Carter *et al.*(1949) (Case 4)
No details	Minimal recovery in tibialis anterior, and contractures of extensor digitorum longus, extensor hallucis longus	Carter *et al.*(1949) (Case 5)
No details	Minimal recovery in tibialis anterior. Foot drop needing apparatus	Carter *et al.*(1949) (Case 6)
No details	Not followed up	Carter *et al.*(1949) (Case 9)
Penicillin, rest, heat	Foot drop requiring later peroneal transplant	Tillotson and Coventry (1950)
Bed rest, heat, repeated aspiration. Fasciotomy fifth day. Wound did not heal. Explored after five weeks; all muscles necrotic	Wound had not healed 7 weeks from onset. Foot drop permanent	Campbell and Van Wagoner (1955) (Case 1)
Bed rest, elevation, heat, for 3 weeks. Then physiotherapy	Permanent foot drop limited by contracture 4 months later	Campbell and Van Wagoner (1955) (Case 2)
Bed rest, paravertebral block; no good. Biopsy twentieth day	Foot drop needing a brace	Campbell and Van Wagoner (1955) (Case 3)

and venules, this would lead to just such patchy areas of congestion and ischaemia as have been described. It would also bring the condition closely into line with peritendinitis crepitans (Howard 1937), in which fatigue is followed by ischaemic changes and local thrombosis in small blood vessels near a musculo-tendinous junction.

Differential diagnosis—Once the surgeon is aware of the entity its characteristic history and unmistakable signs make the diagnosis obvious. There should be no difficulty in excluding cellulitis, fracture, thrombophlebitis or osteomyelitis by simple clinical examination. Having arrived at a diagnosis of ischaemic necrosis of muscle, it will only be necessary to consider and exclude other causes of ischaemia, such as vascular disease, injury or embolus.

Prevention—By analogy with the prevention of excessive stiffness it seems likely that very gradual training should prevent the development of march gangrene, as suggested by Carter *et al.* (1949). The patient in Case 1, however, had already completed six weeks of infantry training and was in the habit of going for an evening run "just to keep fit." The patient in Case 2, in the interval between developing gangrene in the left and right peroneal muscles, had spent four months on graduated exercise under supervision without ever complaining of discomfort in the unaffected side.

In a case reported by Mavor (1956) severe ischaemic pain in the anterior tibial muscles occurred in an overtrained professional footballer. It might perhaps have gone on to gangrene, though this cannot be proved (Griffiths 1956). This patient was treated by letting a gusset of fascia lata into the fascia of each anterior tibial compartment. No other chronic case of this nature has been reported: on the contrary most have been of sudden onset. We therefore doubt whether prevention is feasible and we certainly do not recommend that medical officers should encourage soldiers to fall out whenever their shins ache.

Treatment—The results of treatment in previously recorded cases are set out in Table IV. In only one patient did complete recovery of function in a muscle occur—in this case after fasciotomy on the fourth day (Sirbu, Murphy and White 1944). One patient made a partial recovery after incision of a supposed abscess (Carter, Richards and Zachary 1949), which would amount to a restricted fasciotomy. Three other recorded patients underwent operation at three, four and six days respectively without recovery.

The patient in our own Case 2, whose leg was decompressed within thirty hours, recovered completely. In Case 1 operation was delayed until the ninth day, yet it brought great immediate relief to the patient and was followed by partial recovery of the muscle, and complete recovery of the nerve lesion.

We regard march gangrene as a surgical emergency. We do not hesitate to recommend early and extensive fasciotomy as the treatment. Failure to decompress the muscle in good time can only result in permanent and severe disability. It is not possible to say, in terms of hours or days, when it will be too late for surgical intervention, because the factors that govern the survival of the muscle (the metabolic reserve, the elasticity of the fascia and the extent of vascular thrombosis) will vary from case to case. Obviously the earlier the muscle is decompressed, the better will be its chance of ultimate recovery. But lapse of time alone does not forbid operation, as previous authors have maintained on slender evidence.

On the other hand, necrotic muscle is easily infected. If infection should occur, the wound will not heal until all the necrotic muscle has sloughed away, or has been removed (Horn 1945, Moretz 1953). Infection is a very real danger, especially in these cases where the wound inevitably gapes with the expansion of the decompressed compartment. Great care must be taken to prevent contamination of the wound during and after operation, but such precautions should be taken in many surgical operations. They are not permitted to prevent surgery from being carried out when it is necessary. We submit that in march gangrene urgent surgical decompression of these strangulated muscles is absolutely necessary, and that no other treatment is of the slightest use.

SUMMARY

1. Three cases are described in which ischaemic necrosis of certain leg muscles followed exercise.
2. Previous reports of this condition are analysed, and the histology is discussed.
3. The term march gangrene is suggested for this condition.
4. The treatment advised is early and extensive fasciotomy.

We are very grateful to Dr J. W. Landells for examining and reporting on the biopsy specimens of our cases. We wish to thank Mr E. J. Crawford for the biopsy from Case 3, Squadron Leader C. B. Wynn-Parry, M.B.E., for the report on the electromyogram of Case 2, and Mr John King, of the Bernhard Baron Institute of Pathology the London Hospital, for the photomicrographs.

REFERENCES

ADAMS, R. D., DENNY-BROWN, D., and PEARSON, C. M. (1953): Diseases of Muscle. London: Cassell & Company Ltd.

BELL, J. (1826): The Principles of Surgery, Vol. 2, p. 163. Ed. Charles Bell. London: T. Tegg.

BLOMFIELD, L. B. (1945): Intramuscular Vascular Patterns in Man. Proceedings of the Royal Society of Medicine (Section of Orthopaedics), **38,** 617.

BOWDEN, R. E. M., and GUTMANN, E. (1949): The Fate of Voluntary Muscle After Vascular Injury in Man. Journal of Bone and Joint Surgery, **31–B,** 356.

BROOKS, B. (1922): Pathologic Changes in Muscle as a Result of Disturbances of Circulation. An Experimental Study of Volkmann's Ischemic Paralysis. Archives of Surgery, **5,** 188.

BROOKS, B. (1924): Diseases of the Blood Vascular System of the Extremities. An Experimental Study. Journal of Bone and Joint Surgery, **6** 326.

CAMPBELL, R. E., and VAN WAGONER, F. H. (1955): Ischemic Necrosis of the Anterior Tibial Compartment Musculature. Archives of Surgery, **71,** 662.

CARTER, A. B., RICHARDS, R. L., and ZACHARY, R. B. (1949): The Anterior Tibial Syndrome. Lancet, **ii,** 928.

CASTLE, T. (1831): A Manual of Surgery. Third edition, p. 48. London: E. Cox.

CHILD, C. G., III (1942): Noninfective Gangrene Following Fractures of the Lower Leg. Annals of Surgery, **116,** 721.

CLARK, W. E. LeGros, and BLOMFIELD, L. B. (1945): The Efficiency of Intramuscular Anastomoses with Observations on the Regeneration of Devascularized Muscle. Journal of Anatomy, **79,** 15.

EDWARDS, E. A. (1953): The Anatomic Basis for Ischaemia Localized to Certain Muscles of the Lower Limb. Surgery, Gynecology and Obstetrics, **97,** 87.

GRIFFITHS, D. Ll. (1940): Volkmann's Ischaemic Contracture. British Journal of Surgery, **28,** 239.

GRIFFITHS, D. Ll. (1951): Volkmann's Ischaemic Contracture. (Editorial.) Journal of Bone and Joint Surgery, **33–B,** 299.

GRIFFITHS, D. Ll. (1956): The Anterior Tibial Syndrome: A Chronic Form? (Editorial.) Journal of Bone and Joint Surgery, **38–B,** 438.

HARMAN, J. W., and GWINN, R. P. (1949): The Recovery of Skeletal Muscle Fibers from Acute Ischemia as Determined by Histologic and Chemical Methods. American Journal of Pathology, **25,** 741.

HILL, R. L., and BROOKS, B. (1936): Volkmann's Ischemic Contracture in Hemophilia. Annals of Surgery, **103,** 444.

HORN, C. E. (1945): Acute Ischaemia of the Anterior Tibial Muscle and the Long Extensor Muscles of the Toes. Journal of Bone and Joint Surgery, **27,** 615.

HORN, J. S., and SEVITT, S. (1951): Ischaemic Necrosis and Regeneration of the Tibialis Anterior Muscle After Rupture of the Popliteal Artery. Journal of Bone and Joint Surgery, **33–B,** 348.

HOWARD, N. J. (1937): Peritendinitis Crepitans. A Muscle-Effort Syndrome. Journal of Bone and Joint Surgery, **19,** 447.

HUGHES, J. R. (1948): Ischaemic Necrosis of the Anterior Tibial Muscles Due to Fatigue. Journal of Bone and Joint Surgery, **30–B,** 581.

LEWIS, Sir T. (1936): Vascular Disorders of the Limbs, p. 37. London: Macmillan & Co.

MACQUEEN, I. J. (1954): Recent Advances in the Technique of Progressive Resistance Exercise. British Medical Journal, **ii,** 1,193.

MAVOR, G. E. (1956): The Anterior Tibial Syndrome. Journal of Bone and Joint Surgery, **38–B,** 513.

MIDDLETON, D. S. (1930): The Pathology of Congenital Torticollis. British Journal of Surgery, **18,** 188.

MORETZ, W. H. (1953): The Anterior Compartment (Anterior Tibial) Ischemia Syndrome. American Surgeon, **19,** 728.

PEARSON, C. M., ADAMS, R. D., and DENNY-BROWN, D. (1948): Traumatic Necrosis of Pretibial Muscles. New England Journal of Medicine, **239,** 213.

PHALEN, G. S. (1948): Ischemic Necrosis of the Anterior Crural Muscles. Annals of Surgery, **127,** 112.

PSAKI, R. C., and SCHIELDS, C. D. (1952): Ischaemic Necrosis of the Anterior Tibial Muscle. Archives of Physical Medicine, **33,** 153.

SEVERIN, E. (1943): Umwandlung des Musculus tibialis anterior in Narbengewebe nach Überanstrengung. Acta Chirurgica Scandinavica, **89,** 426.

SIRBU, A. B., MURPHY, M. J., and WHITE, A. S. (1944): Soft Tissue Complications of Fractures of the Leg. California and Western Medicine, **60,** 53.

TAIT, G. B. (1955): Anterior Tibial Syndrome Following Arterial Embolism. (Correspondence.) British Medical Journal, **i,** 1,535.

THOMSON, S. A., and MAHONEY, L. J. (1951): Volkmann's Ischaemic Contracture and its Relationship to Fracture of the Femur. Journal of Bone and Joint Surgery, **33–B,** 336.

TILLOTSON, J. F., and COVENTRY, M. B. (1950): Spontaneous Ischemic Necrosis of the Anterior Tibial Muscle. Report of Case. Proceedings of the Staff Meetings of the Mayo Clinic, **25,** 223.

VOGT, P. R. (1943): Ischaemic Muscular Necrosis following Marching. Unpublished, but read before the Oregon State Medical Society, September 4, 1943. (*Cf.* Horn, C. E. (1945.))

VOLKMANN, R. (1881): Die ischaemischen Muskellähmungen und Kontracturen. Zentralblatt für Chirurgie, **8,** 801. Reprinted in Journal International de Chirurgie (1938), **3,** 77.

WATSON, D. C. (1955): Anterior Tibial Syndrome Following Arterial Embolism. British Medical Journal, **i,** 1,412.

WRIGHT, S. (1952): Applied Physiology. Ninth edition, p. 19. London, New York, Toronto: Geoffrey Cumberlege Oxford University Press.

METAPHYSIAL FRACTURES IN INFANCY

W. J. WESTON, LOWER HUTT, NEW ZEALAND

From the Department of Radiology, Hutt Hospital, New Zealand

The subject of fractures in infancy has been discussed by several authors including Caffey (1946), Silverman (1953), Astley (1953), and Woolley and Evans (1954). These fractures are of considerable interest because they can be confused with syphilis, tuberculosis, scurvy, osteomyelitis and malignant tumours. Dr E. B. D. Neuhauser of Boston, discussing Silverman's paper, said: " Our great difficulty is convincing the paediatrician and the orthopaedic surgeon that trauma is the explanation for some of these bizarre and rather unusual bone changes."

CASE REPORTS

Case 1—A boy weighing 6 lb. 5 oz, was delivered at the Hutt Hospital and was the first child of a healthy mother. The infant was delivered as a face presentation after fourteen and a half hours' labour. He was blue at birth and cried weakly at first and was bruised about the lips and chin. An imperforate anus was found and this was treated by incision. There was an erythema of the face and body. The only other finding of note was a loud systolic murmur, loudest at the base of the heart but present in all areas from the second day onwards.

FIG. 1

FIG. 2

FIG. 3

Case 1. Figure 1—Initial radiograph, at age two weeks, showing metaphysial fracture of right radius. There is bone destruction and callus formation. Figure 2—Four months later. Healing is complete. Figure 3—At age five years.

At the age of two weeks a right wrist drop was noted and there was deformity of the wrist. Radiographs showed a fracture through the metaphysis of the radius (Fig. 1). There was bone destruction in this area as well as a little periosteal new bone formation. There was considerable oedema about the fracture site; a syphilitic lesion was considered and the rest of the long bones were radiographed. The long bones of the legs showed zones of osteoporosis in the metaphyses but no other fractures or signs of syphilis were noted. The wrist was strapped.

The laboratory findings were as follows. The Wassermann and Kahn reactions of both parents and child were negative. Red blood corpuscles were 4,700,000 per cubic millimetre, and the haemoglobin was 13 grammes per cent. The white cells totalled 12,100 per cubic millimetre. An anal stenosis and megacolon developed and the general condition of the infant was below average. There was recurrent abdominal distension with vomiting.

FIG. 4

FIG. 5

FIG. 6

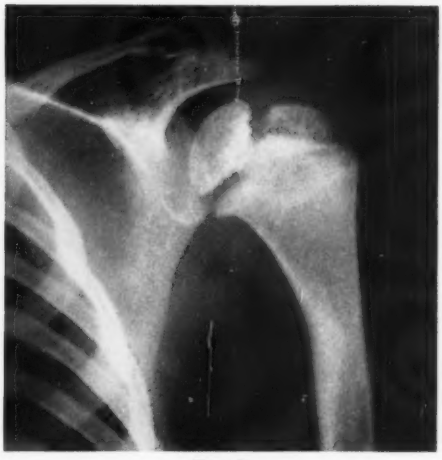


FIG. 7

Case 2. Figure 4—Initial radiograph of left humerus. Figure 5—Four weeks later. Figure 6—Six months later. Figure 7—Two years later.

Further radiographs of the right wrist were taken three weeks later, and considerable repair had taken place, with periosteal new bone formation. Films over the next three months showed a gradual return towards normal with remodelling of the metaphysis (Fig. 2). No other fractures were noted during the next two years and the child made satisfactory progress.

Case 2—A boy aged ten and a half months had a history of falls on to his left shoulder on two successive days a week before he was first seen. The physician noted that the shoulder

was swollen and painful on movement. Radiographs showed a fracture through the metaphysis of the upper end of the left humerus (Fig. 4). There were both bone destruction and new bone formation in this area. There was a little medial and posterior displacement of the proximal fragment. A gauze pad and bandage were applied and the child was sent home.

FIG. 8

FIG. 9

FIG. 10

Case 2. Figure 8—Initial radiograph of femora, showing a metaphysial fracture of the right femoral neck. Figure 9—Two months later. Figure 10—Three months later still.

A further radiograph ten days later showed further displacement of the proximal humeral fragment, which was tilted medially. There was exuberant periosteal callus about the metaphysis and upper humeral shaft.

A skeletal survey showed that there was a further fracture through the metaphysis of the right femoral capital epiphysis, with a little medial and posterior displacement of the proximal fragment (Fig. 8). There were fissure fractures in the metaphyses at the lower ends of the femora, and upper left tibial metaphysis (Fig. 11).

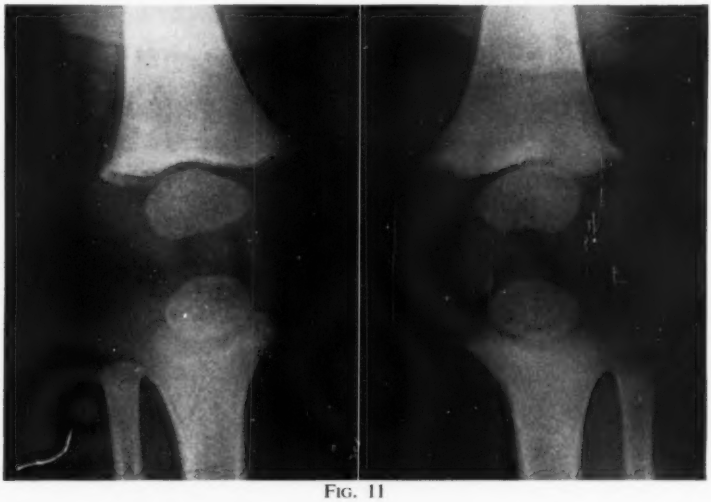


FIG. 11

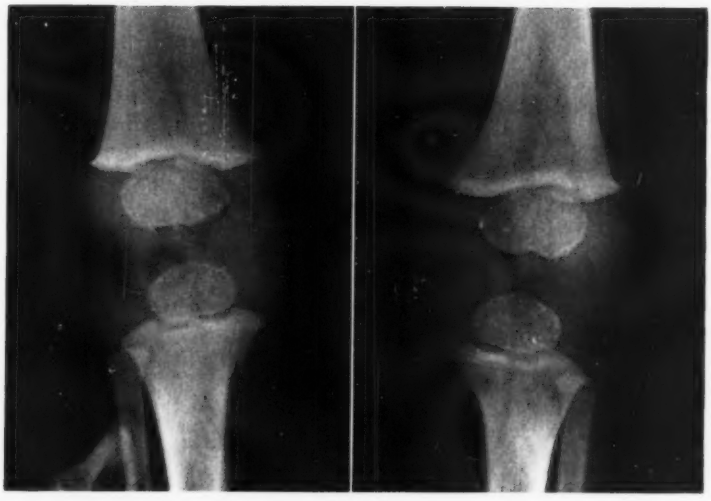


FIG. 12

Case 2. Figure 11—Initial radiographs of knees, showing metaphysial fractures at lower ends of femora. Figure 12—Two months later.

The child was admitted to the Hutt Hospital at the age of one year and the parents gave the history that he was slow to crawl, was constipated and had gained no weight in the last four and a half months. His weight was 20 lb. 3 oz. No abnormality was noted in the heart, lungs or nervous system. There was limitation of lateral rotation, abduction and flexion of the right hip, and these movements were associated with pain. The child was put

in " gallows " traction. During the stay in hospital a persistent and unexplained intermittent pyrexia to 100 degrees Fahrenheit was noted.

The fractures in the lower femora healed and there was further repair at the fracture at the left shoulder (Figs. 5 to 7). No further slipping of the proximal fragment in the right femur occurred, and there was evidence of some repair in the metaphysis. After two months of skin traction he developed a sensitivity reaction to the elastoplast. The patient was discharged home for further rest in bed.

FIG. 13

FIG. 14

FIG. 15

Case 3. Figure 13—Initial radiograph of hips showing metaphysial fracture of left femoral neck. Figure 14—Three and a half months later. Figure 15—Six months later still.

Later radiographs showed further fragmentation in the upper metaphysis of the right femur, and the proximal fragment was displaced still further in a medial and posterior direction (Fig. 9). Six months after the initial films re-ossification was noted in the right upper femoral metaphysis, associated with a varus deformity (Fig. 10). The fractures of the lower femoral metaphyses had healed (Fig. 12).

A year later the child returned to hospital with a supracondylar fracture of the right humerus.

Laboratory investigations showed negative Wassermann and Kahn reactions.

Case 3—A boy, the third full-term infant of a healthy mother, was admitted to the Hutt Hospital at the age of four weeks. He was delivered from a persistent occipito-posterior presentation after an easy labour lasting three hours. His weight at birth was 7 lb. 10 oz. and he was breast-fed. The parents had noted that there was swelling of the left thigh at the age of two weeks and this had increased considerably in the succeeding two weeks. Radiographs of the hip regions showed bone destruction in the metaphysis and uppermost third of the left femoral diaphysis, with considerable irregular callus formation about the fracture site (Fig. 13).

FIG. 16

FIG. 17

Case 3. Figure 16—Initial radiograph of left forearm showing bone destruction in lower metaphysis of ulna, with periosteal new bone formation. Figure 17—Two months later. Healing is well advanced.

There was acetabular dysplasia, with dislocation of the hip. A skeletal survey showed bone destruction also in the metaphysis of the left ulna, with well organised callus about it (Fig. 16). There was further bone destruction in the metaphysis of the lower end of the right femur, with a little periosteal new bone formation. No lesion was detected in the skull or in the spine. There was an unexplained intermittent pyrexia up to 100·3 degrees Fahrenheit throughout this patient's stay in hospital.

Further radiographs five weeks later showed repair in the left ulna with periosteal new bone extending half way up the shaft of the ulna (Fig. 17). Consolidation was taking place in the upper end of the left femur and at the lower end of the right femur.

Three and a half months after the initial radiographic examination the left femoral capital epiphysis had appeared and the dislocation of the left hip was confirmed. There was shortening and remodelling of the femoral diaphysis (Fig. 14). The condition six months later is shown in Figure 15.

Laboratory investigations showed an erythrocyte sedimentation rate of 55 millimetres in the first hour. Haemoglobin was 11·4 grammes per cent. White blood cells totalled 16,000 per cubic millimetre, with lymphocytes 37 per cent and neutrophils 56 per cent. Serum total calcium was 4·55 m.Eq./litre, serum inorganic phosphorus 6·0 milligrams/100 cubic centimetres,

and serum alkaline phosphatase 14·5 K.A. units. Serum potassium was 4·2 m.Eq./litre. The Kahn reaction was negative. Urine concentration of vitamin C was 0·35 milligrams/100 cubic centimetres. The vitamin C content in 20 cubic centimetres urine was 0·07 milligrams.

DISCUSSION

The fractures in the first and third cases were probably caused by obstetrical trauma, as both patients developed signs within the first two weeks of birth, one in hospital and the other after his return home. It was of interest that they were both vertex presentations and were delivered without assistance. Snedecor, Knapp and Wilson (1935) quoted similar findings, but in all their cases the fractures followed breech deliveries.

In Case 2 there was a history of direct injury to the left shoulder on two occasions. After further questioning the parents said that one of their relatives used to play with this child with great vigour and threw him up into the air on many occasions.

Silverman (1953) and Woolley and Evans (1954) pointed out that parents might be unwilling to admit the possibility of injury or even deny it. The history of injury may be given only after direct and close questioning.

The significant feature that emerges from these cases is that, if one metaphysial fracture is found, a skeletal survey should be undertaken to determine if further fractures are present.

Astley (1953) considered that there is some increased fragility of the metaphysis that makes these children prone to injury. This view has not been accepted by other workers, who believe that injury is the sole causative factor.

SUMMARY

1. Three cases of metaphysial fractures in infants are described. Obstetrical trauma was probably responsible in two cases, and in the third case direct injury was admitted by the parents.

2. These fractures are associated with bone destruction and periosteal new bone formation in the metaphyses. They are important because they can be confused with syphilis, tuberculosis, scurvy, osteomyelitis and neoplasm.

3. The fractures respond to conservative treatment and usually heal rapidly in a matter of weeks.

Dr O. C. Moller very kindly made available the follow-up films in Case 2. Mr G. M. Goodson was responsible for the patients' care in Cases 1 and 2. Mr D. T. Beetham, Mr N. M. Menzies and Mr J. H. Saunders have looked after the patient in Case 3. Mr R. B. Sparke was responsible for the radiographic reproductions.

Since this paper was submitted a comprehensive review of traumatic lesions in growing bones has been published by Caffey (1957).

REFERENCES

Astley, R. (1953): Multiple Metaphyseal Fractures in Small Children. British Journal of Radiology, **N.S. 26,** 577.

Caffey, J. (1946): Multiple Fractures in the Long Bones of Infants Suffering From Chronic Subdural Hematoma. American Journal of Roentgenology, **56,** 163.

Caffey, J. (1956): Pediatric X-ray Diagnosis, p. 833. Chicago: The Year Book Publishers, Inc.

Caffey, J. (1957): Some Traumatic Lesions in Growing Bones other than Fractures and Dislocations: Clinical and Radiological Features. British Journal of Radiology, **30,** 225.

Silverman, F. N. (1953): The Roentgen Manifestations of Unrecognized Skeletal Trauma in Infants. American Journal of Roentgenology, **69,** 413.

Snedecor, S. T., Knapp, R. E., and Wilson, H. B. (1935): Traumatic Ossifying Periostitis of the Newborn. Surgery, Gynecology and Obstetrics, **61,** 385.

Snedecor, S. T., and Wilson, H. B. (1949): Some Obstetrical Injuries to the Long Bones. Journal of Bone and Joint Surgery, **31–A,** 378.

Woolley, P. V., Jun., and Evans, W. A., Jun. (1954): Significance of Skeletal Lesions in Infants Resembling Those of Traumatic Origin. Journal of the American Medical Association, **158,** 539.

ARTHRITIS OF HIP COMPLICATING OSTEITIS PUBIS

H. B. COATES MILSOM and B. S. ROSE, ROTORUA, NEW ZEALAND

From the Queen Elizabeth Hospital, Rotorua

A previously healthy man of seventy-four years, a retired farmer, was admitted to another hospital for prostatectomy in July 1954. At that time he had had symptoms of prostatic disease for over four years. A large adenomatous prostate was removed by Millin's retropubic method, and both vasa were tied. There had been a small quantity of residual urine before operation, but it was clear and was not cultured. Progress after the operation was satisfactory for the first few days, but he then suffered a secondary haemorrhage with high fever. The fever was accompanied by a persistent watery diarrhoea, which caused a marked deterioration in the patient's general condition.

One month after the operation he began to have pain in the pubic region, and radiographs showed osteitis pubis. As his general condition was improving he was then discharged after nine weeks in hospital.

After his discharge the pain eased in the pubic region, but spread laterally to the ischial tuberosities, where it became so severe that for several months he was unable to sit in one position for more than a few minutes. He could walk without discomfort until eight months after the operation, when his right hip joint became involved as the pain left the ischial tuberosities. The hip then rapidly became so severely affected that he was unable to walk, or even to move in bed without severe pain.

Nine months after the prostatectomy he was admitted to the Queen Elizabeth Hospital for Rheumatic Diseases at Rotorua with a diagnosis of arthritis of the right hip. At that time he was afebrile, but had to stay in bed for several weeks because of the painful hip. Review of the previous radiographs showed, in the first (undated) film, a normal appearance of the symphysis pubis and hip joint (Fig. 1); but in the second film taken eight months after the prostatectomy, the symphysis pubis appears fused, and there were signs of osteitis and periostitis of the ischio-pubic rami, with early spread to the right hip joint (Fig. 2).

Treatment and progress—The hip was rested at first with sustained traction, and later in a plaster hip spica. He remained comfortable in this for about three months, when he again developed a febrile illness with diarrhoea, and passage of mucopus from which none of the usual intestinal pathogens could be isolated. He failed to respond to streptomycin and aureomycin therapy, but the diarrhoea eventually subsided during treatment with succinyl sulphathiazole. Thereafter he suffered the further complication of left basal pneumonia with pleurisy and pericarditis and was in poor condition for several weeks. During this time the arthritis assumed secondary importance, and nothing further was done for it except to maintain fixation in the hip spica. His recovery was further delayed by an infected ulcer on the right foot, but after a total period of about six months' immobilisation the plaster spica was removed and he was encouraged to walk.

During the course of the illness the right hip joint had continued to show progressive destructive changes, with migration of the acetabulum upwards and outwards, and absorption of the femoral head (Figs. 3 to 5). The patient was finally left with a reasonable range of movement, like that after an excision arthroplasty.

DISCUSSION

Osteitis pubis is a self-limiting disease that seldom spreads beyond the pubic bones. On rare occasions it may, as in our patient, spread to involve the hip joint. Such a case was described by Friedenberg (1950), who was able to find records of two previous cases reported

FIG. 1
Initial radiograph (undated) showing a clear symphysis pubis and normal hip joints.

FIG. 2
Seven months after prostatectomy. Osteitis pubis with fusion of symphysis and early involvement of right hip joint.

FIG. 3

Two months later. Severe involvement of right hip with loss of joint space and migration of acetabulum.

FIG. 4

FIG. 5

Figure 4—Four months later still (one year after prostatectomy and six months after onset of disease in hip). There is moderate absorption of the femoral head. Figure 5—A year later (two years after prostatectomy). Stage of healing in right hip joint following absorption of femoral head.

by Silver (1941). Each of these affections had followed suprapubic operations on the bladder or prostate. In Friedenberg's patient a biopsy showed infection with pseudomonas, for which antibiotics were given; but the destructive process progressed and an extra-articular arthrodesis was eventually performed. In Silver's two cases the disease was arrested without operation.

The cause of osteitis pubis is uncertain: injury with vaso-neurotrophic disorder, and infection with organisms of low virulence, have been suggested (Götzen and Boeminghaus 1953, Abrams, Sedlezky and Stearns 1949). The course of the disease in our patient strongly supports an infective origin in his case, even though no specific organism was isolated. Nevertheless, as in the cases described by Abrams *et al.* (1949), antibiotics did not seem to be helpful.

A self-limited course with healing in one situation and spread in another was observed in the present case both clinically and radiologically. Finally the activity of the hip lesion subsided, permitting moderate function despite severe destruction of the femoral head. It seems likely that in future cases of hip involvement satisfactory natural healing might be expected—as in uncomplicated osteitis pubis—if the joint be maintained in a good position while attention is paid to the general health of the patient.

SUMMARY

1. A case of arthritis of hip complicating osteitis pubis after retropubic prostatectomy is described.
2. It seems likely that bacterial infection was responsible in this case, although it was not proved.
3. Antibiotics did not appear to influence the course of the disease.
4. The progress of the disease was followed clinically and radiologically to its conclusion by natural healing with absorption of the femoral head, leaving a painless joint with good function.

We wish to thank Dr J. Cairney, Director-General of Health, New Zealand, for permission to publish this case report.

REFERENCES

ABRAMS, M., SEDLEZKY, I., and STEARNS, D. B. (1949): Osteitis Pubis. New England Journal of Medicine, **240,** 637.

FRIEDENBERG, Z. B. (1950): Osteitis Pubis with Involvement of the Hip Joint. Journal of Bone and Joint Surgery, **32-A,** 924.

GÖTZEN, F. J., and BOEMINGHAUS, H. (1953): Über die Ostitis pubis. Zentralblatt für Chirurgie, **78,** 1.

SILVER, C. M. (1941): Pelvic Bone Changes Following Suprapubic Prostatectomy. Bulletin of the Hospital for Joint Diseases, **2,** 10.

CHONDROBLASTOMA (CODMAN'S TUMOUR) OF THE THORACIC SPINE

JANUSZ BURACZEWSKI, JANINA LYSAKOWSKA AND WITOLD RUDOWSKI, WARSAW, POLAND

From the Institute of Oncology, Warsaw

A man aged twenty-eight complained of increasing pains in the interscapular region for two and a half years. For two weeks he had noticed weakness of the limbs, disturbances of gait, and unusual sensations in parts of the body. Radiographs showed a "mediastinal tumour." He was admitted to the Institute of Oncology in Warsaw in May 1954. On

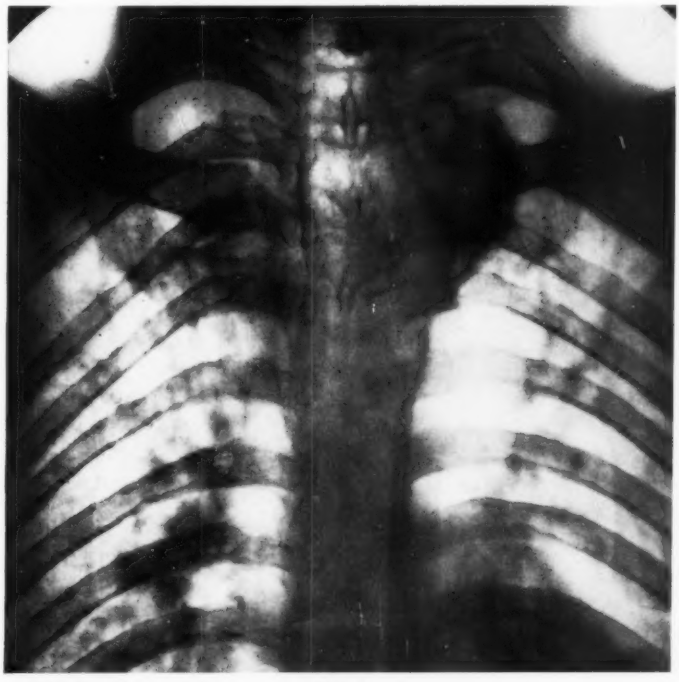


FIG. 1

Radiograph showing the mass in the left paravertebral space above the clavicle. Note the peripheral calcification about the upper pole of the tumour. There is destruction of the left part of the arch of T.3 and probably also of T.4.

examination the upper part of the thoracic spine showed scoliosis to the right. There was local tenderness at the level of the third and fourth thoracic vertebrae. The tone of the muscles in the lower limbs was increased, especially on the left. Muscle power in the lower limbs was diminished, more distinctly on the left side and decreasing distally. Abdominal reflexes were absent. The patellar reflexes were accentuated on both sides, with definite preponderance of the left. The calcaneal tendon reflexes both gave a clonic response, more marked on the left. The Oppenheim reflex was negative on both sides, the Rossolimo reflex was slightly positive on the left side, and the Babinski reflex was positive on both sides, especially the

left. Superficial sensibility was absent below the level of the fifth thoracic segment, and temperature sensation was weakened to the same level. Deep sensibility was normal. The Romberg test provoked a distinct tremor of the lower limbs, and the patient tended to fall

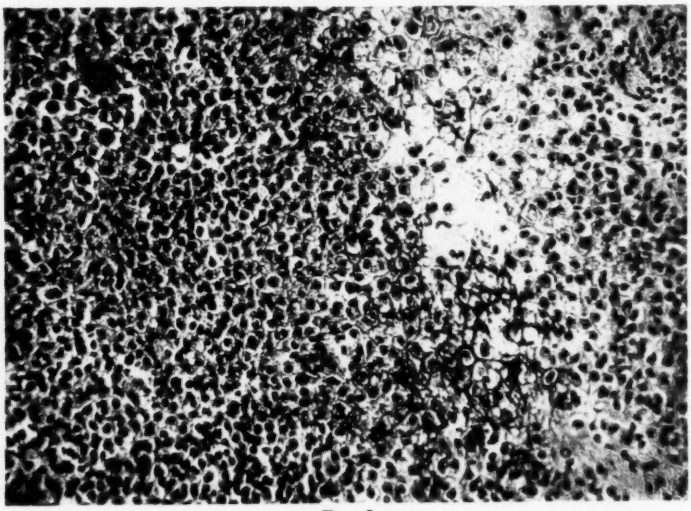


FIG. 2

Photomicrograph of the tumour. Multicellular foci and " clip-like " calcifications can be seen among the cells. On the right is a focus of degeneration.

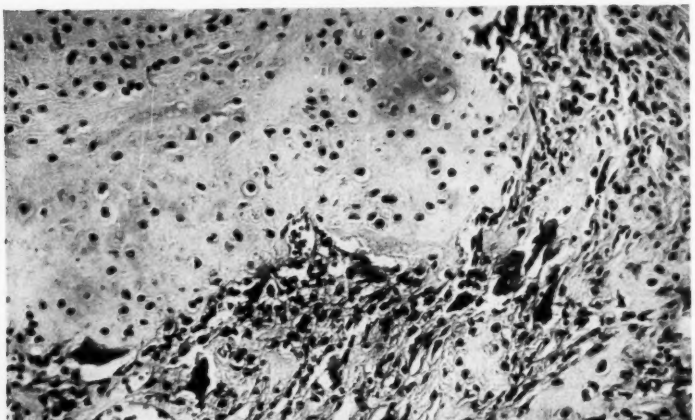


FIG. 3

Photomicrograph of the tumour. On the left side is a cartilaginous field. On the right side hyalinisation of the stroma is seen. Note the vessels encircled with osteoclasts.

forwards and to the left. The gait was irregular and spastic. In brief, the neurological examination showed spastic paresis of the lower limbs, more marked on the left side, suggesting compression of the spinal cord at the level of T.3–4.

Radiographs showed a mass above the left clavicle, adjacent to the spinal shadow and the size of an egg. It did not pulsate, showed somewhat granular structure, and had at the periphery an incomplete calcified shell about a millimetre thick (Fig. 1). Further radiographs showed partial destruction of the neural arches of the third, and probably also the fourth, thoracic vertebrae on the left side. The medial end of the third rib was not distinctly seen. The radiological diagnosis was not clear, but the possibility of an atypical tuberculous process was suggested because of calcification on the periphery and the irregular structure of the mass. Aspiration biopsy produced a jelly-like material which, examined histologically, showed the typical structure of a chondroblastoma (Professor J. Laskowski).

Operation (June 1954) (W. Rudowski)—Laminectomy was performed at the level of T.3–4. The spinal cord appeared to be pushed to the right side and it did not pulsate. Pinkish-grey masses which bled readily were present inside the spinal canal, pushing the cord aside. The masses were located in the epidural space, entering the spinal canal through the intervertebral foramen at the level of T.3–4. This part of the tumour was resected, leaving a cavity with diameters $2{\cdot}5 \times 1{\cdot}5$ centimetres. The spinal cord returned to its normal position and began to pulsate. The already enlarged intervertebral foramen was still more enlarged by partial resection of the transverse processes, and the content of the posterior mediastinal tumour was so removed that only the calcified shell was left. Bleeding was stopped by plugging. The post-operative course was uneventful, with only slight pleural effusion on the left side. The paretic symptoms gradually disappeared, and in three weeks the patient could walk with comfort. A post-operative course of radiotherapy (4,500 r) was given to the tumour area.

The patient was discharged in good general condition. Two years later he was free from symptoms and in good general health. Strangely enough the radiological picture was nearly the same as before operation: evidently the cavity left after removal of the tumour filled with scar tissue.

Pathological examination of material removed at operation showed small fragments of reddish-grey tissue, in parts soft and in other places more indurated, like elastic cartilage. Histological examination confirmed the previous diagnosis of chondroblastoma (Figs. 2 and 3).

DISCUSSION

This case is remarkable for the histological structure of the tumour (Codman's tumour is a rarity no matter where it is situated), for its unique localisation in the thoracic spine, and for its shape (hour-glass tumour of the spine), its puzzling radiological appearances, and the favourable outcome.

In 1931 Codman selected a group of nine tumours among giant-cell tumours in the collection of the Bone Sarcoma Registry of the American College of Surgeons, and described them as "epiphysial chondromatous giant-cell tumours of the upper end of the humerus." Previously other authors, including Ewing (1928), Geschickter and Copeland (1931) and King (1931) had described tumours with similar structure under various names. These tumours were afterwards studied by Jaffe and Lichtenstein (1942) and by Copeland and Geschickter (1949). Separate cases were described by Coley and Santoro (1947), Hammarström (1934), and Ardao (1943). Recently eight cases were published by Valls, Ottolenghi and Schajowicz (1951). One case with typical localisation was described by Urban (1955). The term benign chondroblastoma introduced by Jaffe and Lichtenstein is now in common use.

Chondroblastoma is a rare tumour of bone. In 1955 Urban collected thirty-seven cases from the literature. Three cases were seen in the Institute of Oncology in Warsaw (including the one reported) and three others were verified microscopically among other bone tumours by Professor J. Laskowski.

The histological picture of this tumour is characterised by the variability of its structure. Neighbouring fields with completely different character correspond to the different developmental tendencies of the neoplastic tissue and to the changes occurring in it. The

main mass of the tumour is composed of fields with roundish cells of small or medium size, with scanty eosinophilic cytoplasm and a distinct, round or oval, centrally situated, clear nucleus with nucleolus. Among these thickly packed cells one can see single multinuclear giant cells of the osteoclast type. In other fields the cells are more loosely packed and separated by scanty intercellular substance with " clip-like " calcifications, which gives the appearance of a honeycomb, this being the most characteristic feature of the structure of this tumour. In other fields the intercellular substance is scattered with scanty cells. This intercellular substance undergoes hyalinisation. It is eosinophilic and envelops single cells lying in lodges, gradually resembling the appearance of fibrous cartilage. Radically different pictures may be present also, such as clear fields of necrosis with pale pink stained liquefied intercellular matrix, shadows of cells and fields of massive calcification. These pictures correspond to

FIG. 4
A typical chondroblastoma in the greater tuberosity of the humerus (authors' case).

the changes taking place in the tumour. Those appearances are supplemented by multiple young blood vessels in the connective tissue, abundant extravasations of blood, and singly dispersed osteoclasts which give to the whole picture a multicoloured, versatile appearance.

The diagnosis of the benign chondroblastoma may be established solely on the basis of the histological examination, but it must be emphasised that in spite of the characteristic microscopical appearance it may remain unidentified. Even experienced pathologists not acquainted with this pathological entity may interpret the tumour structure erroneously.

The tumour is commonly confused with giant-cell tumour, chondrosarcoma and osteo-chondro-sarcoma. The most important histological feature is the presence of "clip-like" calcifications around the cells and the presence of chondromatous areas among fields with abundant cells and osteoclasts.

Agreement has not yet been reached on the pathogenesis of this tumour. Some authors suppose that it originates from embryonal chondroblasts (Lichtenstein and Kaplan 1949). Copeland and Geschickter (1949) and Laskowski (1955) connected the origin of the tumour with the epiphysial cartilages of long bones in the growing stage. Opinions differ also about the malignancy of the tumour. Most authors regard it as exclusively benign. Others, notably Copeland and Geschickter, try to distinguish forms of chondroblastomata with an unfavourable clinical course. Theoretical considerations and existing descriptions suggest the possibility that some chondroblastomata are malignant. At any rate such possibilities should be taken into account when treatment is being planned. Insufficiently radical operations should be avoided as liable to provoke malignant transformation of the tumour. The malignant form of chondroblastoma might be called " malignant chondroblastoma " or " chondroblastic sarcoma." In most cases this tumour is found in the young. In Jaffe and Lichtenstein's (1942) series the ages of the patients lay between thirteen and seventeen years, and in Copeland and Geschickter's (1949) series between ten and twenty-four. The latter authors suggested that there might be a correlation between the duration of symptoms and the age of the patients. In older persons symptoms may last for a considerable time. Such was the case with our patient aged twenty-eight with symptoms lasting for several years.

Most commonly pain is the first symptom to evoke attention. Pain is usually persistent and well localised. At a later stage change of configuration may be seen at the site of the tumour. Disturbance of the function of the limb may follow. Occasionally a joint effusion may be present.

Chondroblastomata occur most often at sites that normally show the most rapid growth of bone. Thus they are most often found in the upper end of the humerus, lower end of the femur, and the lower and upper ends of the tibia (Fig. 4). They are much more common in men (80 per cent) than in women.

In typical cases the radiological appearances may be quite characteristic, permitting an early diagnosis of chondroblastoma. It is manifest in oval, translucent areas, well demarcated, sometimes with a shell-like calcified periphery, seldom with marked expansion of bone. Typical are the small spot-like calcifications in the tumour, distinguishing it from giant-cell tumours of bone. Large chondroblastomata are less common than large giant-cell tumours. Other cases, however, present radiological features that are much more difficult to interpret. In the standard manual of radiology edited by Schinz *et al.* (1950) the tumour is reproduced presenting small, round, translucent areas not very sharply demarcated. In other cases the boundary of the tumour may be effaced and the destruction may pass to the metaphysis and even the diaphysis of the bone. The radiological features in such cases suggest a malignant tumour. In many cases the radiological differential diagnosis must take into consideration such tumours as osteogenic sarcoma, chondrosarcoma and non-malignant tumours such as chondroma, fibromata and chondromyxoid fibroma. Even non-neoplastic conditions such as eosinophilic granuloma, cystic tuberculosis and dysplasias must be considered as possibilities.

Final diagnosis must be confirmed by histological examination, which is essential if malignant change is to be excluded. A thorough knowledge of the pathology of Codman's tumour is necessary to avoid the catastrophic results of misdiagnosis such as have been described in the literature (Coley 1949).

Most of the cases so far described have been treated surgically. Usually the tumour has been exposed and curetted, with quite favourable results. But to guard against possible malignancy it would be preferable to excise the whole tumour more radically whenever possible.

Little is known about the value of radiotherapy. Two patients out of eight described by Valls *et al.* (1951) were successfully treated by radiotherapy. One patient was so treated in our Institute but the tumour continued to grow; so it was later excised with a margin of the surrounding bone, and it has not recurred.

SUMMARY

1. A left-sided, paravertebral, hour-glass tumour causing destruction of the neural arches of the third and fourth thoracic vertebrae with evidence of spinal cord compression, is described. The tumour presented the typical histological appearance of a chondroblastoma.

2. The intraspinal part of the tumour was excised and the mediastinal part curetted. Post-operative radiotherapy was given. The patient was symptomless two years after operation.

3. No example of Codman's tumour with similar features and in such a situation has been described before in the literature. Pathological, clinical and radiological aspects of chondroblastomata are briefly discussed and some remarks concerning their treatment are added.

REFERENCES

ARDAO, H. A. (1943): Sarcoma condroide del húmero. Boletin de la Sociedad de Cirugia del Uruguay, **14,** 225.

CODMAN, E. A. (1931): Epiphyseal Chondromatous Giant Cell Tumors of the Upper End of the Humerus. Surgery, Gynecology and Obstetrics, **52,** 543.

COLEY, B. L. (1949): Neoplasms of Bone. New York: Paul B. Hoeber, Inc.

COLEY, B. L., and SANTORO, A. J. (1947): Benign Central Cartilaginous Tumors of Bone. Surgery, **22,** 411.

COPELAND, M. M., and GESCHICKTER, C. F. (1949): Chondroblastic Tumors of Bone: Benign and Malignant. Annals of Surgery, **129,** 724.

EWING, J. (1928): The Classification and Treatment of Bone Sarcoma. Report of the International Conference on Cancer, London, 17th–20th July 1928, p. 365. Bristol: Printed for the British Empire Cancer Campaign by John Wright & Sons Ltd.

GESCHICKTER, C. F., and COPELAND, M. M. (1931): Tumors of Bone. New York City: The American Journal of Cancer.

HAMMARSTRÖM, S. (1934): Ein Fall von Chondroblastischem Sarkom. Acta Radiologica, **15,** 668 (after Valls).

JAFFE, H. L., and LICHTENSTEIN, L. (1942): Benign Chondroblastoma of Bone. American Journal of Pathology, **18,** 969.

KING, E. S. J. (1931): An Example of Benign Osteogenic Sarcoma. British Journal of Surgery, **19,** 330.

KOLODNY, A. (1927): Bone Sarcoma. The Primary Malignant Tumors of Bone and the Giant Cell Tumor. Surgery, Gynecology and Obstetrics, **44,** Supplement 1, 1.

LASKOWSKI, J. (1955): Personal communication.

LICHTENSTEIN, L., and KAPLAN, L. (1949): Benign Chondroblastoma of Bone. Unusual Localization in Femoral Capital Epiphysis. Cancer, **2,** 793.

PHEMISTER, D. B. (1930): Chondrosarcoma of Bone. Surgery, Gynecology and Obstetrics, **50,** 216.

SCHINZ, H. R., BAENSCH, W. E., FRIEDL, E., and UEHLINGER, E. (1950): Lehrbuch der Röntgendiagnostik. Fünfte Auflage. Stuttgart: Georg Thieme Verlag. Band 1.

URBAN, A. (1955): Chondroblastoma benignum. Nowotwory, **5,** 153.

VALLS, J., OTTOLENGHI, C. E., and SCHAJOWICZ, F. (1951): Epiphyseal Chondroblastoma of Bone. Journal of Bone and Joint Surgery, **33–A,** 997.

WILLIS, R. A. (1953): Pathology of Tumours. Second edition. London: Butterworth & Co. (Publishers) Ltd.

THE RELIEF OF TRAUMATIC ARTERIAL SPASM IN THREATENED VOLKMANN'S ISCHAEMIC CONTRACTURE

A. BENJAMIN, LONDON, ENGLAND

Senior Orthopaedic Registrar, Charing Cross Hospital, London

The etiology of Volkmann's contracture has been much debated. Incorrect bandaging (Volkmann 1881), venous occlusion (Murphy 1914, Brooks 1922, Jepson 1926), subfascial haematoma (Moulonguet and Senèque 1928, José Jorge 1925), arterial spasm (Griffiths 1940) are some of the causes that have been suggested. Leriche (1928) likened the changes in the muscles to those seen in cardiac and pulmonary infarction. In the forearm, muscle necrosis may affect the extensors as well as the flexors; this distribution can be explained by attributing the necrosis to arterial occlusion (Seddon 1956).

Massart (1935) observed that the muscles were infiltrated by a sero-haemorrhagic exudate and that they appeared ready to burst. Personal observations at operation on patients suffering from limb injuries with vascular complications suggest that the presence of oedema alone in a neighbouring fascial compartment may be an important etiological factor.

CASE REPORTS

Case 1—A man aged twenty-five years fractured the middle of the shaft of his left tibia and fibula in a motor cycle accident. On admission to hospital four hours later the foot was blue and cold. The popliteal region and calf were swollen, and neither the popliteal pulse nor the foot pulses were palpable.

The fracture was reduced, and six and a half hours after the accident a spinal anaesthetic was given, but the circulation in the foot did not improve; therefore the popliteal fossa was explored through a longitudinal incision. No bleeding was seen from the skin or deeper structures, and the popliteal artery could not be identified although the vein was traced throughout the length of the popliteal fossa. The incision was extended down to the level of the ankle, and, on division of the deep fascia of the calf, the muscles bulged out. The popliteal artery dilated at once and the operation field began to bleed. The foot regained its normal colour, and the pulses became palpable. The fascia and skin edges were three inches apart, and since they could not be sutured without interfering with the circulation the wound was packed with vaselined gauze. A well padded plaster was applied and bivalved. The systolic blood pressure did not fall below 125 millimetres of mercury during the operation. Two weeks later secondary suture was carried out, and the limb subsequently recovered its full function.

Neither haematoma nor damaged tissues were seen at any stage of this operation. The fracture haematoma remained deep to the fascia on soleus; yet the uninjured gastrocnemius was oedematous. Immediately the tension in this oedematous muscle was released the spasm in the popliteal artery disappeared.

Case 2—A girl aged seven years fell on her outstretched hand and sustained a supracondylar fracture of the left humerus. On examination the fingers were cold and the radial pulse was not palpable. Four hours after the injury gentle manipulation under general anaesthesia failed to reduce the fracture, and, because of the circulatory impairment, exploration was carried out immediately.

The cubital fossa was exposed and found to contain a haematoma, and the neurovascular bundle had been impaled by the distal end of the proximal humeral fragment. Distal to the spike the artery was threadlike and did not pulsate; proximal to the spike it was normal. The neurovascular bundle was dissected free, a local periarterial sympathectomy was performed

and a 2·5 per cent solution of papaverine sulphate was applied to the artery. These measures failed to relieve the spasm. The deep fascia enclosing the flexor muscles of the forearm was then incised longitudinally and the muscles burst out, having been under tension from oedema. There was no sign of injury distal to the elbow and no spread of haematoma into the forearm muscles. Warm packs were applied, and, after twenty-five minutes, the arterial spasm disappeared, the wound began to bleed and the radial pulse became palpable at the wrist. The fracture was reduced and as the skin edges could not be approximated a split-skin graft was applied. The systolic blood pressure did not fall below 115 millimetres of mercury during the operation, and no change (of blood pressure) occurred at the time that the spasm relaxed. The limb was immobilised on a plaster slab and later made a complete recovery.

Case 3—A girl aged sixteen injured her left forearm, causing separation of the lower radial epiphysis with slight displacement. On examination, within two hours of the injury, the fingers were blue and cold, and the radial pulse was not palpable.

The wrist was manipulated under general anaesthesia and a plaster slab applied, but there was no improvement in the circulation. A brachial plexus block was followed by return of the radial pulse. Four hours later the hand again became blue and cold and the radial pulse impalpable.

Under general anaesthesia a longitudinal incision was made on the flexor aspect of the forearm. When the fascial compartment of the flexor group was incised the muscles bulged out and the circulation in the hand recovered immediately. There was a haematoma in the distal third of the flexor muscles, all of which were oedematous. An attempt was made to suture the fascia, but the radial pulse was obliterated when the sutures were tightened; therefore the wound was packed with vaselined gauze. Secondary suture, two weeks later, was followed by complete recovery.

In this case the arteries were not seen, and therefore the existence of the spasm was not proven. However, the transient improvement in the circulation of the hand which followed brachial plexus block suggests that the impairment of the blood supply was due partly to arterial spasm.

DISCUSSION

There is considerable evidence to show that incision of the fascia enclosing the flexor muscles of the forearm may prevent irreversible ischaemic changes (Murphy 1914, José Jorge 1925, Jepson 1926, Moulonguet et Senèque 1928, Massart 1935). In this paper an attempt is being made to relate this with the view that Volkmann's ischaemic contracture is due to arterial occlusion (Griffiths 1940, Šeddon 1956).

In Cases 1 and 2 tension in muscle groups distal to arterial spasm was due to oedema and was not associated with haematoma, sero-haemorrhagic exudate or other signs of injury. In Case 3, although haematoma was present, oedema was a prominent feature. The oedema causing tension in these muscles might be due to arterial spasm and not to direct injury. It is possible that soon after the appearance of spasm the anoxia from diminished blood flow (Cohen 1940) causes increased capillary permeability and exudation of fluid. Tension mounts in the flexor muscles of the forearm, or the calf muscles of the legs, because they are enclosed by unyielding fascia.

There is a tendency for an artery in spasm to relax spontaneously provided the systemic blood pressure remains within normal limits (Kinmonth 1952); therefore when spasm persists without obvious local cause it is desirable to look further afield. My observations suggest that tension from oedema in a neighbeuring fascial compartment may be the stimulus that maintains the spasm. Thus a vicious circle is set up, in which the increased tension maintains the arterial spasm, and the consequent ischaemia aggravates the oedema and hence the tension in the fascial compartment.

Spasm of an artery is occasionally seen when it is being handled at operation, and may spread for several centimetres (Rob and Eastcott 1957). It may be by such a mechanism that

tension on an artery, or its branches, causes or maintains spasm of the main vessel several centimetres away.

If this supposition be correct, two fascial compartments may have to be explored, because the cubital or popliteal fossa can be opened without releasing tension in the neighbouring ischaemic muscle group.

SUMMARY

1. Three cases of traumatic arterial spasm are reported.
2. In each case there was increased tension in a neighbouring myofascial compartment.
3. The cause of this tension was oedema, possibly supplemented in one case by haematoma.
4. Release of tension by splitting the sheath was followed by relaxation of the artery.
5. It is suggested that tension in a fascial compartment may provide the stimulus that maintains arterial spasm and that the consequent ischaemia aggravates the oedema, so that a vicious circle is established.
6. It is further suggested that if spasm persists in spite of the usual measures, including exploration of the artery, the distal myofascial compartment should be decompressed. Division of the deep fascia of the cubital or the popliteal fossa is not enough.
7. Such persistent arterial spasm is uncommon, and further observations are needed to define the significance of increased tension in a distal myofascial compartment.

I would like to thank Mr G. J. Lillie and Mr M. Salz of Plymouth, and Mr J. L. Stephen and Mr H. G. Eastcott of London, for allowing me to report these cases which were under their care.

My thanks are also due to Mr H. J. Seddon, Mr H. Jackson Burrows and Mr M. Brett for their criticism of this paper.

REFERENCES

BROOKS, B. (1922): Pathologic Changes in Muscle as a Result of Disturbances of Circulation. Archives of Surgery, **5,** 188.

COHEN, S. M. (1940): Traumatic Arterial Spasm. Guy's Hospital Reports, **90,** 201.

GRIFFITHS, D. Ll. (1940): Volkmann's Ischaemic Contracture. British Journal of Surgery, **28,** 239.

JEPSON, P. N. (1926): Ischaemic Contracture. Annals of Surgery, **84,** 785.

JORGE, J. (1925): Rétraction ischémique de Volkmann. Rapport d'Albert Mouchet. Bulletins et Mémoires de la Société Nationale de Chirurgie, **51,** 884.

KINMONTH, J. B. (1952): The Physiology and Relief of Traumatic Arterial Spasm. British Medical Journal, **i,** 59.

LERICHE, R. (1928): Surgery of the Sympathetic System. Annals of Surgery, **88,** 449.

MASSART, R. (1935): La maladie de Volkmann. Revue d'Orthopédie, **3.** sér. **22,** 385.

MOULONGUET, P., and SENÈQUE, J. (1928): Syndrome de Volkmann. Bulletins et Mémoires de la Société Nationale de Chirurgie, **54,** 1,094.

MURPHY, J. B. (1914): Myositis. Journal of the American Medical Association, **63,** 1,249.

ROB, C. G., and EASTCOTT, H. H. G. (1957): Personal communication.

SEDDON, H. J. (1956): Volkmann's Contracture. Treatment by Excision of the Infarct. Journal of Bone and Joint Surgery, **38–B,** 152.

VOLKMANN, R. (1881): Die ischaemischen Muskellähmungen und- Kontrakturen. Zentralblatt für Chirurgie, **8,** 801. (Reprinted Journal International de Chirurgie, 1938, **3,** 77.)

DISLOCATION OF THE SHOULDER COMPLICATED BY COMPLETE RUPTURE OF THE AXILLARY ARTERY

Successful Suture of the Artery in an eighty-seven-year-old Man

BERTIL STENER, GOTHENBURG, SWEDEN

From the Department of Surgery I, Sahlgrenska sjukhuset, University of Gothenburg

In October 1956 a man aged eighty-seven was admitted to the hospital after having fallen half an hour previously. On examination he was found to have sustained an antero-inferior dislocation of his right shoulder. The arm was ischaemic, without palpable wrist pulse. Only a slight local haematoma was then present. Under anaesthesia, reduction was immediately performed by the Hippocratic manipulation. Soon after the reduction a large haematoma began to appear in the axilla. There was still no palpable radial pulse. The systolic blood pressure, 220 millimetres Hg. at the time of admission, now rapidly dropped to 60 millimetres Hg. Energetic shock therapy was given. It was not obvious from the beginning that there was a rupture of the main artery to the arm. It was considered possible either that the large vessels in the axilla were compressed by the haematoma, the arterial blood pressure presumably having sunk below the pressure of this, or that they were in spasm. To find out if the first alternative was correct an attempt was made to puncture the haematoma with a wide bore needle, but only a few clots were obtained. The stellate ganglion was then blocked with Xylocain in an attempt to release any spasm. This procedure also failed, and the haematoma continued to increase. The entire axilla was now filled with blood almost to bursting point. It was decided to explore the lesion.

Operation—Through a delto-pectoral approach the pectorales major and minor were divided. Large amounts of partly coagulated blood were evacuated. A violent arterial haemorrhage then set in. After the subclavian artery had been compressed against the first rib the axillary artery was found completely severed immediately below the origin of the subscapular artery. There was a moderate degree of arteriosclerosis in the walls of the vessels. As the ends of the artery at the site of the rupture were shredded, about half a centimetre of each had to be resected. The subscapular branch was ligated. An end-to-end anastomosis of the axillary artery was performed with a continuous over-and-over suture of number 5–0 arterial silk. The radial pulse returned immediately. A vein about 5 millimetres wide (probably a branch to the axillary vein) was ligated. The brachial plexus appeared intact macroscopically. Rents that were found in the subscapularis tendon and in the joint capsule were left without suture. Part of the pectoralis major was sewn over the anastomosis.

Progress—The post-operative course was uneventful. Before the operation the patient had been completely paralysed and anaesthetic in his hand and fingers. Immediately after awakening from the anaesthetic he had regained voluntary movements of his fingers, but there was a definite diminution of the power of active extension in the three ulnar ones. The radial pulse was strong and just as good as on the left side. For the first eight days after the operation streptomycin and penicillin were given. On the fifth day anticoagulant treatment with Sintroma (Geigy) was started and continued for about two weeks. At first the arm was fixed in slight abduction, but after two weeks active movements were encouraged. Four weeks after the operation the patient could raise the arm to a right angle (Fig. 1). Radiographs of shoulder showed a minor compression of the greater tuberosity.

Eight months after the operation the patient still had a strong radial pulse. The extension weakness in the three ulnar fingers had regressed considerably. As this paresis was limited

to certain fingers, it was ascribed to a partial injury of the brachial plexus caused by the dislocation or possibly by the reduction. The paraesthesia, present in the hand shortly after the operation, had disappeared. The sensibility was good. The skin temperature and colour were similar in both hands. He was now able to raise his arm almost as much as on the uninjured side.

DISCUSSION

It is very unusual for shoulder dislocations to be complicated by injuries to the vessels. Less than a hundred cases have been described in the literature since 1825. These complications were previously more frequent than in more recent years. In 1911 Guibé collected seventy-eight cases, most of which were from the nineteenth century. The reduced frequency in more recent years is probably explained by old dislocations being much more unusual now than before. A contributory reason is that the rather rough manipulations that were sometimes used have now been discarded. It is reported in the literature that up to ten men have used their combined

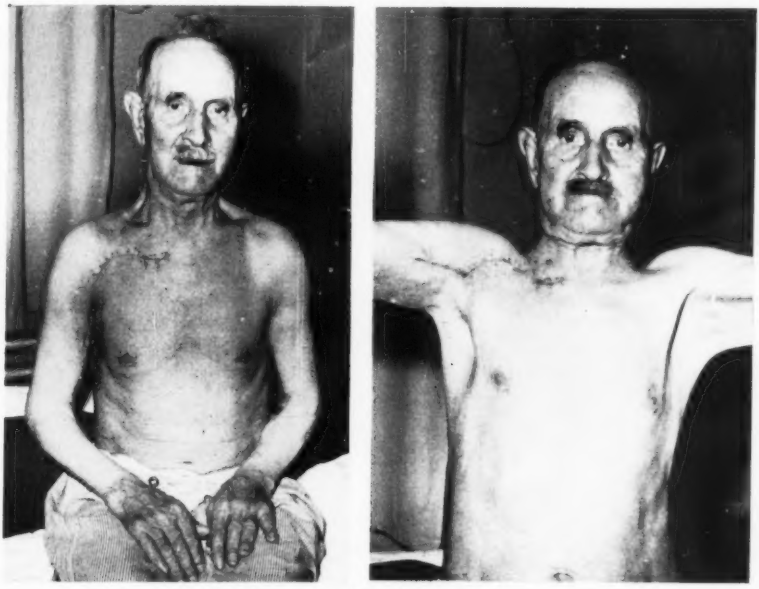


FIG. 1
The patient four weeks after the operation.

force in manipulating an old shoulder dislocation, resulting in vessel damage (Delpeche quoted by Guibé). Relaxing narcosis is also important in preventing vessel complications during reduction, as well as the use of operative reduction for old dislocations.

Among the cases described arterial damage has been of different types and degrees. There may be only intimal damage with local thrombosis, one of the branches may be torn from the axillary artery, or there may be a partial or complete rupture of the main artery. I have found only twelve authentic reports of total rupture of the axillary artery caused by shoulder dislocation. As to the site of the arterial lesion, it is typical that a large branch is torn at its origin from the axillary artery (often the subscapular or circumflex humeral arteries) or that the main artery itself ruptures where a large branch originates and acts as a bridle on the arterial trunk.

Vascular injuries have occurred more often at reduction of old dislocations than of fresh ones. Less than one in ten of the cases published have been ascribed with certainty to the

dislocation itself. However, it does not necessarily mean that the injury to the vessel was not present before the reduction, even if it was not discovered until afterwards. In some cases the suggestion has been made that the humeral head in its displaced position has stopped the haemorrhage before the reduction (Körte 1902, Guibé 1911, Buchanan 1912, Drescher 1935). In the present case it is difficult to state with certainty whether the rupture occurred in connection with the dislocation or at the reduction. The absence of a large haematoma at the time of admission points against there having been any severe haemorrhage from the axillary artery before the reduction. On the other hand, the arm was ischaemic and without radial pulse when the patient arrived at the hospital. It is possible that the rupture—caused by the dislocation—was immediately closed by the humeral head.

The prognosis for arterial injuries complicating shoulder dislocations has been generally poor. Of the ninety cases collected from the literature by Calvet, Leroy and Lacroix (1941-42) no less than forty-nine were fatal. The remaining patients, with few exceptions, lost their arm or else the arm lost its function to a great extent. Theoretically, it is possible to ligate the axillary artery and still to preserve the circulation in the arm; but in practice the results have been unsatisfactory in vessel injuries caused by shoulder dislocations. The collateral circulation often becomes impaired at the actual dislocation or reduction. The enormous haematoma will also contribute to this impairment, and so will the operation, at which it is necessary to cut through a good deal of muscle to expose the injury.

In a few instances attempts have been made to suture the damaged axillary artery. Körte (1902) repaired a hole in the side of the artery, but he was later obliged to ligate the artery because of secondary haemorrhage. The final result was considerable invalidity of the arm. Lexer (1907) reported a case in which after resecting the ruptured ends, he bridged the defect with a saphenous vein graft. After the operation the patient suffered delirium tremens, and died on the fifth day from circulatory insufficiency. At the necropsy the graft and the suture lines were free from thrombosis, but the lumen of the artery was half obliterated by a clot attached to the wall where a clamp had been applied to the proximal stump. Buchanan (1912) described a case of fracture-dislocation of the shoulder in which the fractured humeral head had caused a transverse laceration of the axillary artery. The damaged segment was resected, and an end-to-end anastomosis was performed. "The hand soon recovered its heat," but the patient did not regain any distinct radial pulse. Schirmer (1932) made an end-to-side anastomosis, but was obliged to disarticulate the shoulder on account of later haemorrhage. The patient died after a few hours. Drescher (1935) reported a case in which arterial suture had been tried, but gangrene supervened.

Recently Henson (1956) described two cases in which he had performed a successful end-to-end anastomosis of the axillary artery. In one case there was an intimal injury with local thrombosis caused by a displaced fracture of the surgical neck in a man aged sixty-five. In the other case—that of a man aged seventy-two—a typical subcoracoid dislocation had caused a complete severance of the axillary artery, aneurysmally dilated in consequence of arteriosclerosis.

The possibility of performing a successful arterial suture in an injury to the axillary artery caused by shoulder dislocation has, according to the literature, generally been regarded with scepticism. This injury often occurs in elderly persons with arteriosclerotic vessels, and, from the nature of the injuring force, the ends of the artery are generally torn to a great extent, and must be resected more or less. The possibility of the patient's regaining good function of the arm after ligation of the stumps of the artery is, however, limited—and in old persons even less than in young ones, because the collateral vessels are arteriosclerotic.

After having obtained a successful result in the case reported here I agree with Henson that advanced age is an indication rather in favour of, than against, suture of the artery in cases of this type.

SUMMARY

A case of complete rupture of the axillary artery in a man aged eighty-seven is described. The injury occurred in connection with an antero-inferior dislocation of the shoulder. It is not known whether the rupture was caused by the dislocation itself or by the reduction. A successful suture of the artery was performed. A review of the literature is given, and earlier attempts to suture the artery in cases of this type are noted. The indications for this operation are discussed.

REFERENCES

BUCHANAN, J. J. (1912): Circular Resection and Suture of the Axillary Artery for Transverse Laceration by Fracture-Dislocation of Anatomical Neck of the Humerus. Surgery, Gynecology and Obstetrics, **15,** 648.

CALVET, LEROY, and LACROIX (1941–42): Luxations de l'épaule et lésions vasculaires. Journal de Chirurgie, **58,** 337.

DRESCHER, K. (1935): Über Gefässschädigungen bei Luxationen und deren Repositionen. Archiv für klinische Chirurgie, **184,** 361.

GUIBÉ, M. (1911): Des lésions des vaisseaux de l'aisselle qui compliquent les luxations de l'épaule. Revue de Chirurgie, **44,** 580; 916.

HENSON, G. F. (1956): Vascular Complications of Shoulder Injuries. Journal of Bone and Joint Surgery, **38-B,** 528.

KÖRTE, W. (1902): Ein Fall von Arterien-Verletzung bei Verrenkung des Oberarmes. Arteriennaht. Nachblutung. Unterbindung Heilung. Archiv für klinische Chirurgie, **66,** 919.

LEXER, E. (1907): Die ideale Operation des arteriellen und des arteriell-venösen Aneurysma. Archiv für klinische Chirurgie, **83,** 458.

SCHIRMER, H. (1932): Ruptur der Arteria axillaris bei Schulterluxation. Zentralblatt für Chirurgie, **23,** 1,433.

THE ROLE OF ABDOMINAL PRESSURE IN RELIEVING THE PRESSURE ON THE LUMBAR INTERVERTEBRAL DISCS

D. L. BARTELINK, LONDON, ONTARIO

From the Department of Anatomy, Medical School, University of Western Ontario

Every writer who has interested himself in the mechanics of the lumbar spine has been struck by the great magnitude of the forces that operate when a person bends forwards and lifts a heavy weight. So long as a person is upright, even if he carries a heavy weight in his hands, the pressure upon the spine is not more than the sum of the upper trunk and the weight—that is, a few hundred pounds. However, if he bends forwards and picks up a heavy weight the spine begins to act as part of a crane and tremendous torque forces appear. Most writers seem to shy away from mentioning the outcome of their calculations and only call the forces " enormous " or " terrific." Bradford and Spurling (1945) calculated that a muscle pull of 1,500 pounds, exerted by the erector spinae muscles, and operating on a lever of two inches, is necessary to counterbalance a load of 100 pounds lifted by the hands at a distance of thirty inches in front of the fulcrum—the lumbo-sacral disc! The pressure in the disc is the sum of these loads—that is, 1,600 pounds—indeed justifying the term tremendous, if one considers that the area of pressure is not much greater than one square inch.

One can object to the assumption of Bradford and Spurling that the lever in front of the fulcrum would be as long as thirty inches. If it is less the pressure on the disc is proportionately smaller. On the other hand, a weight of 100 pounds acting on the long lever is only a modest representation of what actually can be lifted by a strong man; and to this weight should be added the weight of head and shoulders. Let the lever be only fifteen inches, but let us assume that he lifts 200 pounds plus fifty pounds (head, shoulders and thorax), then the pressure in the lumbo-sacral disc will be 2,000 pounds. This calculation is based upon stationary forces. The pressures that appear during violent action according to this reasoning must be considerably higher and can only be characterised as enormous.

How does the spine and especially how do the intervertebral discs stand up under this pressure?

EXPERIMENTS ON THE RESISTANCE OF DISCS TO PRESSURE

Virgin (1951) tested intervertebral discs, removed from the cadaver together with a thin slice of bone on each side, in an Olson compression machine. He found that at a load of about 300 pounds the disc loses some fluid and gets (very slightly) thinner, but that this process is completely reversible if one allows the disc, which is kept in saline, to reabsorb fluid after decompression. At higher loads (no specific load was given; 1,000 pounds was the greatest load mentioned) a condition comparable to the yielding of steel under tension is observed, associated with irreversible changes. Tears in the annulus fibrosus appear, sometimes with prolapse of material from the nucleus pulposus.

I repeated the experiments of Virgin, taking a few precautions that seemed necessary. Preliminary tests had shown that if only a thin slice of bone was left on the disc on each side, as in Virgin's experiments, the bone might tear apart before the annulus suffered damage. I therefore examined discs between two nearly complete vertebral bodies. The sawcuts were made as nearly parallel as possible. The neural arches were removed at the pedicles, because it is possible that some force might be transmitted through the apophysial articulations if these are not entirely vertical. The discs were necropsy specimens, one-half to two days old, that had been kept well refrigerated. So far as our small series (ten discs) allowed us to see,

the lapse of time after death has no influence on the resistance of the disc. It might be of value to check this resistance versus time after death on a larger series of specimens to see if the discs in the living body might have a greater resistance than we are now assuming. In view of the low metabolism of the discs it seems improbable that a sudden change would occur immediately after death.

The discs were subjected to accurately measured loads by a Baldwin materials testing machine, kindly put at our service by the General Motors Diesel Plant in this city. At each step of the increasing pressure the deformity was checked by means of a gauge reading to a thousandth of an inch. The discs all behaved in the same way (Fig. 1). First there was a region of settling, where the deformity was rather great relative to the rise in pressure. This was followed by a straight part of the curve where the disc essentially behaved as a perfectly elastic body, the deformity increasing proportionally to the pressure. It should be noted

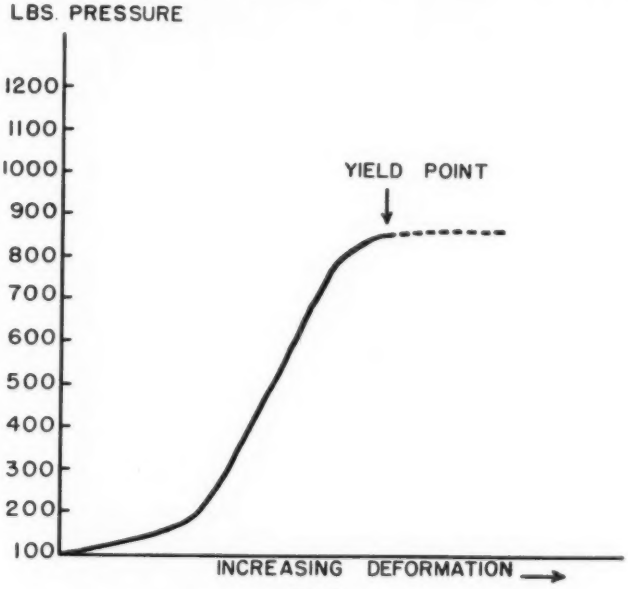


FIG. 1

This graph shows the relationship between deformity and load for an average disc. If the experiment is continued after the yield point has been passed the deformity is seen to increase rapidly, and the load necessary to cause this deformity falls below that of the yield point.

that, during this elastic response, if one allowed the same pressure to stay for a considerable length of time the deformity increased very slowly, probably because minute quantities of fluid were squeezed out of the disc material. This very slow "creep" started to increase rapidly at certain pressure. If at that level (which may be called the yield point) the pressure was raised another 50–100 pounds the deformity increased rapidly with evident complete destruction of the disc. The yield points were different for each disc, and ranged between 350 and 1,400 pounds, with a mean of 710 pounds, in the ten discs that were examined. There was no evidence of a relationship between the slope of the straight part of the curve and the point of yielding.

It is necessary to note here that most of the discs that we examined were from people of sixty to eighty years of age. When dissected after the compression experiment nearly all of them showed old tears, and those with marked internal damage showed less resistance than

the others. We found some difficulty in obtaining specimens from younger subjects. We were able to test the lumbar 3–4 disc of a man of forty-five who had died of chronic myelogenous leukaemia. His skeleton did not show evidence of involvement. This disc broke down completely with a pressure of 750 pounds. Dissection showed that the chief reason for the collapse was a large number of vertical fractures (fractures in a cranio-caudal direction) some of which were running radially. Corresponding with the fractures, the cartilage plates and the discs showed tears that in the central area were deep enough to let the nucleus material escape, but towards the margin of the disc were much more shallow.

Not many conclusions can be drawn from this experiment, and it seems certainly necessary to do a great number of tests on discs of younger people. Nevertheless it is possible that what

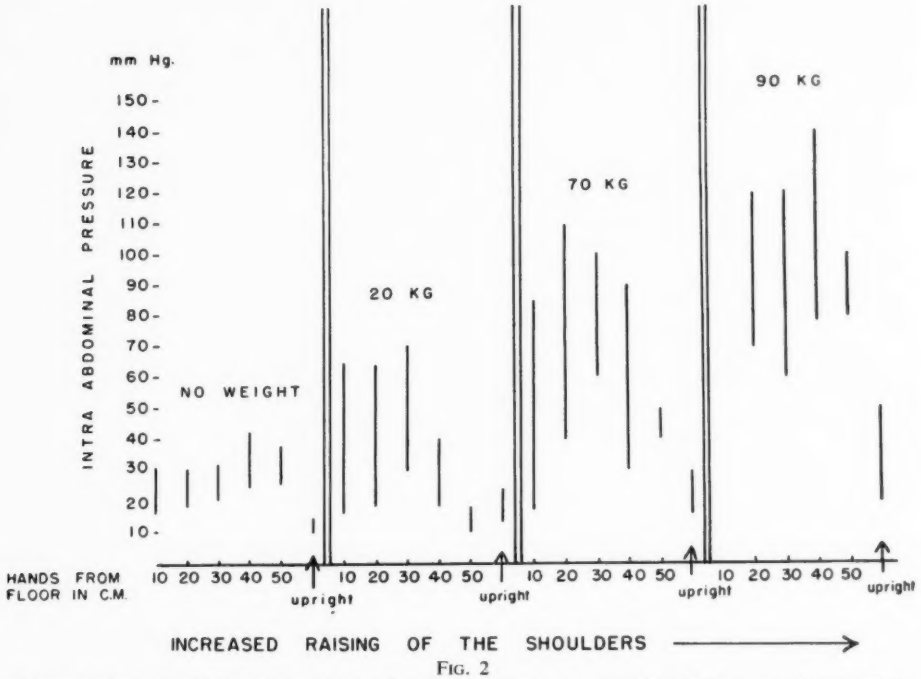


FIG. 2

This graph shows the values of intra-abdominal pressure measured on a powerfully built man aged twenty-three. The pressures were taken with four different loads in the hands. At each of these loads the values were determined in different degrees of bending, designated by giving the distance of the hands from the floor. The vertical lines represent the fluctuations that occurred when the subject breathed, the higher value being the inspiration, the lower the expiration. As is evident the pressures are higher for heavier lifting and are not significantly elevated when the subject is upright.

has been described above happens more often than we realise. It must be remembered that radiographs generally would not show the kind of fractures just described, and that the skeleton of a person who leads a physically easy life may not be much stronger than that of the man who died from leukaemia. Experiments on the pressure resistance of dissected vertebral bodies suggest that the bony part of the spine is much stronger than the discs. However, conditions in such experiments are more favourable for isolated bodies than if they were combined with discs, because the great hydrostatic pressure that is set up in the nucleus pulposus under load causes tangential forces that act not only on the annulus fibrosus, but also on the adjoining bone. It is possible that under such circumstances the annulus would turn out to be the stronger. Yet the disc would suffer in such a case, especially as the tear

in the cartilage plate would open up the disc for the entry of blood vessels along the scar tissue that is formed. As the tears in the cartilage plate seem to appear in the centre first, this would explain why most of the degenerative changes of the discs are seen in the centre.

It is evident from these experiments that the intervertebral discs (and the vertebral bodies) in actual life cannot be subjected to the pressures calculated by Bradford and Spurling and by ourselves (above), as they would not be able to withstand them. We have to review our reasoning, and as we can hardly doubt the correctness of the rather simple mechanical calculation we should ask: is there any other structure besides the spine that might take care of part of the load? At first sight it seems unreasonable to assume any pressure transfer through the trunk other than by the spine, because all the structures are soft. However, soft material can be arranged in such a way that use is made of its tensile strength, rather than its rigidity, to transmit presssures—for instance a football.

THEORY OF ADDITIONAL SUPPORT FOR THE SPINE

Heavy weight lifting is always associated with marked increase in the intra-abdominal pressure. It is not even necessary to measure this pressure to know that it is there, because well known symptoms of weight lifting are congestion and redness of the head and frequently expulsion of a hernia. If one measures the pressure, as we did with a balloon in the stomach connected by a narrow plastic tube to a manometer, the pressure is found to increase with the amount of weight lifted, and to be different in bending over to different degrees (Fig. 2). In extreme flexion of the trunk the pressure is not so high as when the hands are ten to fifteen inches away from the floor, in which position the pressure reaches its greatest. If the lifter continues slowly to straighten out, the pressure drops rather rapidly and is already low with the body still bent over 15–20 degrees. In the upright position, whatever the load in the hands, the pressure is usually very low and never significant. The maximum pressures vary with the individual. Athletic people showed pressures of 140 millimetres of mercury, slightly built people sometimes not more than 60 millimetres of mercury. If the body is flexed without a weight being lifted the pressure is only slightly increased. The greater the amount of weight taken in the hands the more the pressure rises, up to the maximum. If a certain position of flexion, with a given load in the hands, is maintained for a few moments one notices that the intra-abdominal pressure fluctuates considerably with the respiration and in the weaker subjects may fall to zero during expiration even with a maximal lifting effort. The pressure rises sharply if the lifter makes a sudden effort to lift a weight that is almost too much for him. During the measurements it was also noted that sudden straightening out of the body after it had been bent over is accompanied by an initial high spike of intra-abdominal pressure; and if a person flexes forwards and suddenly stops this movement a high spike of pressure is seen at the instant of stopping.

In my experiments the equipment to measure the sudden high elevations of pressure was not available. This was unfortunate because I believe that the essential part of the phenomenon studied—namely, the reflex contraction of the abdominal wall muscles—lasts only a very short time. What was seen in the subjects studied was partly this reflex, but partly also the (subconscious) voluntary contraction with which they maintained the position.

All these observations make it clear that there is a relationship between effort involving the trunk, especially sudden effort, and the intra-abdominal pressure. Could this pressure play a significant role in the mechanics of the trunk?

That the tensed abdomen may act as a support is understood if one imagines that in a skeleton one had wedged a large balloon between the costal margin and the pelvis, fastening it to the costal margin. One could then remove the metallic rod out of the spine of the skeleton—maybe replacing it with a cord—and the skeleton would not collapse forward, because the thorax would be supported by the balloon.

In the living body the costal margin also is attached to a sort of " fluid ball " that will resist deformation as soon as the pressure within it is raised. It is easily conceivable that in this way some of the load of the upper trunk is transmitted, via the somatic cavity, down to the pelvis by what could be called an additional or " muscular skeleton " (Fig. 3).

CALCULATION OF THE AMOUNT OF SUPPORT THAT IS PROVIDED BY INTRA-ABDOMINAL PRESSURE

It is interesting to calculate what amount of support would be provided. Let us consider the thrust transmitted by the diaphragm to the lower thoracic cage. If the area of the cross section of the fluid ball at the level of the lower thoracic aperture is 500 square centimetres and if the pressure per square centimetre is 100 millimetres of mercury, then the total force is

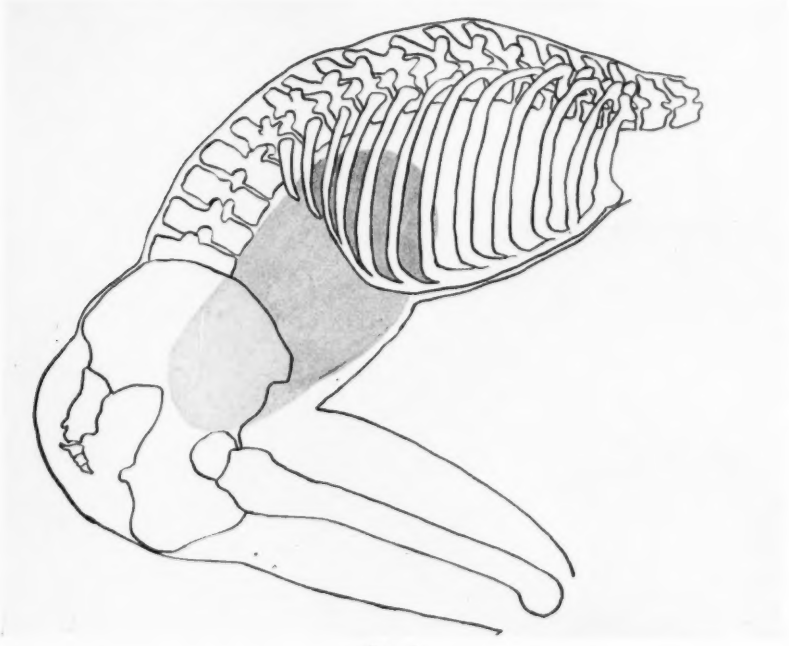


FIG. 3

Diagram to suggest how the abdominal fluid ball, as it is attached to the costal margin, would provide some support for the upper trunk, in case of lifting with the trunk flexed forward.

68 kilograms or 150 pounds. If it would seem that this is a small force compared with the loads as calculated for the spine, we should not forget that this force acts on a lever of considerable length. This lever is much longer than the one on which the erectores spinae act, and the influence upon reducing the necessary pull of the erectores will be proportionately larger. It is hard to give a reliable figure for the length of the lever of the diaphragmatic thrust, but it would seem safe to say that the pressure in the intervertebral disc need not be so high as calculated, by several hundred pounds. As the fluid ball support is a support of which the magnitude can be and evidently is regulated by the body according to the requirements it is reasonable to assume that the pressures in the spine are kept within safe limits by means of this regulation (so long as it holds). Under very severe circumstances increasing the intrathoracic pressure after closure of the glottis may supply an additional force.

EXPERIMENTS ON THE BEHAVIOUR OF THE ABDOMINAL WALL DURING LIFTING

One difficulty with the understanding of this mechanism is the distribution of the tensions in the anterior abdominal wall. It might seem that longitudinal pull of the muscles would obviate the thrust under the diaphragm. With electromyographic studies of the abdominal wall during weight lifting it was found that the rectus abdominis muscles, which are mainly concerned in longitudinal pull, do not contract. The influence of the vertical component of the pull of the oblique muscles is uncertain for the moment. The electromyographs suggested that perhaps the main action responsible for raising the intra-abdominal pressure is supplied by the transverse abdominal muscles which do not have a significant vertical component. What we found regarding the absence of action of the abdominal recti during weight lifting fits in perfectly with what Floyd and Silver (1950) found for the behaviour of the abdominal wall during straining: that there is no action of the recti.

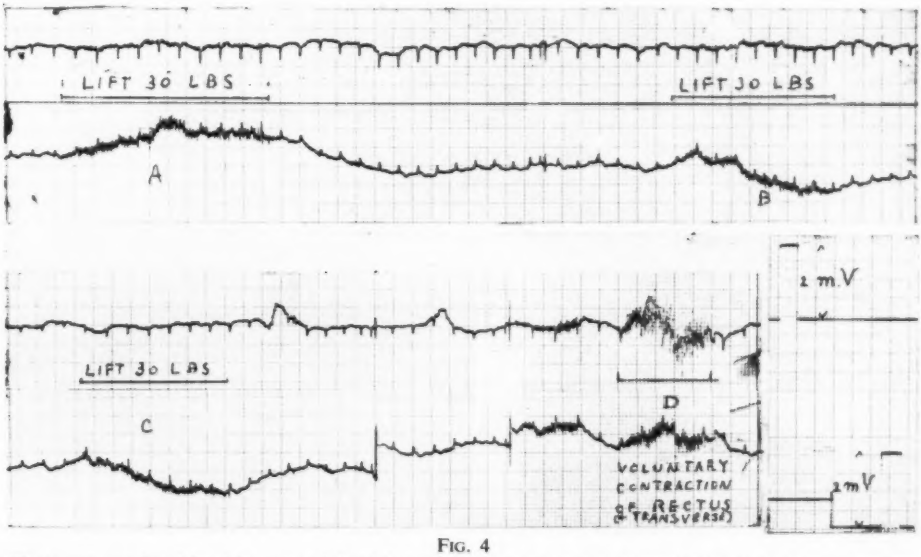


FIG. 4

Electromyographs of the right rectus abdominis muscle (uppermost and third tracings) and of the muscle group composed of the transversalis and the internal and external oblique muscles (second and fourth tracings). The electrodes for this latter group were positioned, one in the right loin close to the lateral margin of the erector spinae, and the other one at the same level anteriorly and about four inches to the right of the midline.

The subject lifted a weight of thirty pounds in the outstretched hands while standing upright, at A, B and C. At D he was asked to force his head down on his chest, which made his recti contract. No weight was lifted at D. The lower right corner tracings show the calibration of each lead for two millivolts.

It is evident that during weight lifting there is no significant contraction of the recti.

The electromyographic study (Fig. 4) in which the muscle action of the abdominal wall was examined during weight lifting was carried out as follows. At first I tried to examine the abdomen of the flexed subject, but found that this was unsatisfactory owing to the shifting of electrodes and poor readings. It seemed that because of the flexion of the trunk the thickness of the abdominal fat became relatively greater and increased the insulation. I therefore made the subject stand upright, and asked him to lift a weight with the horizontally outstretched arms. In experiments with a gastric balloon we had found that in this position also the intra-abdominal pressure rose characteristically. The results are shown in Figure 4. The abdominal recti do not show significant action currents, whereas the lateral muscles do. That the electrodes were correctly placed is shown by the tracing when the recti are voluntarily contracted.

DISCUSSION

The observations and considerations that have been mentioned make it probable that there exists an additional support for the body outside of the spine. This support is the tensed abdomen, the tension appearing through reflex contraction of certain muscles. The reflex probably at least partly is a conditioned reflex. It is interesting to consider that the transverse abdominal muscle anatomically belongs to the same group as the diaphragm and the transverse thoracic muscle. Together with the muscles of the pelvic floor, the origin of which is less certain, they are the muscles that surround the " fluid ball " and by their contraction create the " muscular skeleton " much in the same way as invertebrates are able to create a support that enables them to drive forward the front end of their bodies. The abdominal fluid ball according to this reasoning would be genetically very old, and part of the reflex might even be an inborn reflex.

There is a clinical application of the understanding of this reflex. It is a common clinical observation to find the abdomen of patients with prolapsed or ruptured disc and nerve root pain to be remarkably tense. While spasm of the muscles of the back has easily been understood in " disc trouble," that of the anterior muscles of the abdomen has not been understood. Also it may be that specific training by physical therapy in the raising of the intra-abdominal pressure as a protection for the spine might be of great benefit to patients recovering from " slipped disc " or operations upon the spine.

From observations on a few patients, and also from personal experience, it seems probable that many people could make a better use of the abdominal pressure support to prevent low back pain by putting it into operation voluntarily. The consequences of increased intra-abdominal pressure, especially upon the circulation, are many and seem to deserve further study.

The importance of the abdominal fluid ball support for animals in general—Animals undoubtedly make an extensive use of the protection of their spines by the tensed somatic cavity, and probably also use it as a support upon which muscles of posture find a hold (besides the spine). In this respect it is interesting that the area of the intervertebral discs of a medium-sized gorilla is equal to or smaller than that of a small man (Schultz 1953). The gorilla probably compensates for this by having an enormous somatic cavity and powerful, well developed muscles.

The position of the lungs outside the fluid ball is an obvious advantage. Breathing can go on even when the abdomen is used as a support and cannot be relaxed. This means that the range of flight of an animal having the lungs outside the fluid ball is greater than that of an animal who has its lungs in the single body cavity, which can just make a spurt and then has to stop to breathe. Could it be that it is for this reason that the mammals have developed a diaphragm?

SUMMARY

1. Since the publication by Bradford and Spurling in 1945 of *The Intervertebral Disc*, there has been argument about the figure of 1,600 pounds that they calculated as the load on each lower lumbar intervertebral disc when a person lifts a heavy load with the trunk flexed, especially since experiments have shown that intervertebral discs subjected to increasing pressures yield at values well below this figure. In the author's experiments the discs were destroyed by pressures ranging from 350 to 1,400 pounds, with a mean of 710 pounds.

2. It occurred to the writer that the spine is not necessarily the only structure in the body that can transmit pressure forces from the shoulder to the pelvis. A raised intra-abdominal pressure impacts a thrust under the diaphragm, which will be transmitted to the thoracic spine and the shoulders by means of the ribs. This thrust can take care of part of the lifted weight and thus decrease the load on the spine.

3. In experiments in which the intra-abdominal pressure was measured by means of a small balloon in the stomach it was found that the pressure rose proportionally with the amount of weight lifted.

4. It is suggested that the abdominal fluid ball can exert a longitudinal force only if there is no contraction of the longitudinal muscles (at least anteriorly). Electromyographic studies of the abdominal muscles during weight lifting showed that the transverse and possibly the oblique abdominal muscles contract, but not the recti.

5. It thus seems that the load on the intervertebral discs is not necessarily so great as Bradford and Spurling calculated, but can remain within safe limits. It is hard to give accurate figures for the amount of load that is taken off the spine in this way, but an estimate would put it at several hundred pounds. The importance of a reflex contraction of the abdominal wall during effort as a protective mechanism for the spine must therefore be appreciated. Voluntary contraction may also be called upon to increase the intra-abdominal pressure and so reduce the load on the discs. This is done by many weight lifters.

We have to thank Dr H. A. Skinner, Professor and Head of the Department of Anatomy, and Dr Alan Burton, Professor of Biophysics, for important suggestions and help during the research, and Professor J. C. Paterson and the staff of the Department of Pathology of Westminster Hospital, London, for the intervertebral discs they kindly put at our disposal. Dr Norman Welford, visiting research fellow in the Department of Biophysics, Mr R. Mason and Mr Gerd Froese gave valuable assistance in the electromyography. The co-operation of the students who acted as subjects, and of the management and the staff of the laboratory of General Motors Diesel Limited, London, in the work on the discs is also gratefully acknowledged.

This work has been supported in part by a grant from the Medical Division, National Research Council of Canada, and has been facilitated by the x-ray equipment donated by the J. P. Bickell Foundation.

REFERENCES

BRADFORD, F. K., and SPURLING, R. G. (1945): The Intervertebral Disc. Springfield, Illinois: Charles C. Thomas.

FLOYD, W. F., and SILVER, P. H. S. (1950): Electromyographic Study of Patterns of Activity of the Anterior Abdominal Wall Muscles in Man. Journal of Anatomy, **84,** 132.

SCHULTZ, A. H. (1953): The Relative Thickness of the Long Bones and the Vertebrae in Primates. American Journal of Physical Anthropology, **N.S. 11,** 306.

VIRGIN, W. J. (1951): Experimental Investigations into the Physical Properties of the Intervertebral Disc. Journal of Bone and Joint Surgery, **33–B,** 607.

POSTERIOR DISLOCATION OF THE SHOULDER

STUART SCOUGALL, SYDNEY, AUSTRALIA

The purpose of this paper is to discuss certain factors that determine recurrence in both anterior and posterior dislocations of the shoulder, and to consider the treatment of primary posterior dislocation. My observations are based upon a case of posterior dislocation reduced by operation, and upon experiments in which the glenoid labrum was detached from the margin of the glenoid fossa in a monkey.

CASE REPORT

A carrier aged sixty-one years awoke one night to find himself sitting on the floor, with no knowledge of how he got there. Four days later he complained of stiffness of the left shoulder, and radiographs showed a posterior dislocation, with an extensive defect of the humeral head (Fig. 1). The patient was not aware of any previous dislocation, but he recalled having had a " seizure " nine years before. The dislocation was reduced, and the reduction was confirmed radiographically. The limb was supported by a sling and binder. After a week a further radiograph showed that the dislocation had recurred spontaneously, without the knowledge of the patient and while the arm was still supported. The shoulder was in the typical position of partial abduction and medial rotation.

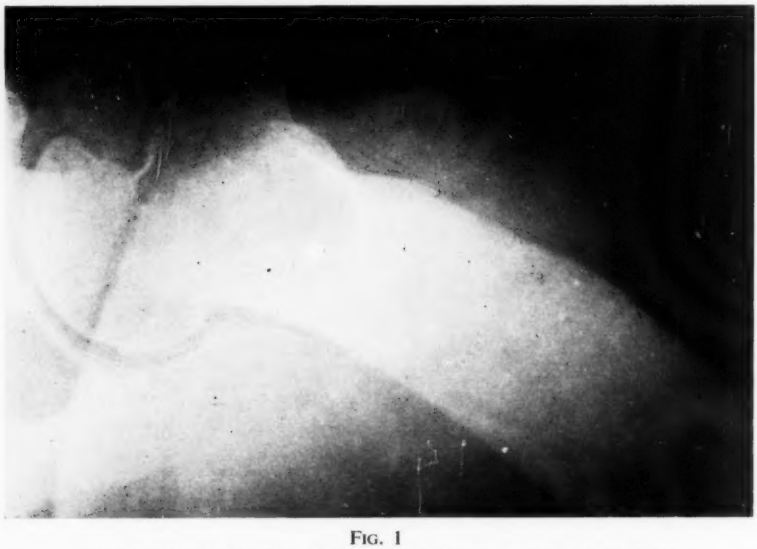


FIG. 1
Infero-superior radiograph of left shoulder showing humeral head defect.

Operation—At operation there was found to be an extensive labral and capsular detachment. There was no fracture of the glenoid margin and no evidence of a congenital defect of the glenoid fossa. The humeral head defect was demonstrated, and it was clear that the notch was compressed against the glenoid rim by the combined action of the stretched capsule and the muscles. This made reduction difficult, even under direct vision. Reduction could be achieved only by forcibly extending the arm and rotating it laterally while direct pressure was

applied upon the humeral head from behind. In this way the humeral head could be lifted over the edge of the glenoid. The dislocation could be readily reproduced, under anaesthesia, by placing the arm in the customary sling position of adduction and medial rotation and applying gentle backward pressure upon the humeral head. It seemed clear that retention of the limb in this usual sling position was an important factor in the early redislocation. After

FIG. 2

Infero-superior radiograph of a normal right shoulder with the humerus in abduction, extension and lateral rotation. It is clear that in this position of the arm posterior dislocation could not occur without considerable distraction, because of the relatively increased elevation of the posterior rim of the glenoid. Distraction would be rendered difficult by the presence of taut anterior soft structures. The radiograph with the arm in this position also indicates the minimal length of the resultant buttress of healing posteriorly, after reduction of a fresh posterior dislocation.

the operation the arm was supported on a frame with 60 degrees' abduction and in lateral rotation and full extension for six weeks. So far the shoulder has remained stable, and function is normal.

DISCUSSION

The first factor that tends towards recurrence of a shoulder dislocation is delay in diagnosis. It is obvious that the chance of effective repair becomes less the longer the shoulder remains dislocated. The remaining factors that require consideration are the damage to the head of the humerus, the manner and duration of retention of the shoulder after the dislocation has been reduced, and the nature of the soft-tissue injury and its capacity for repair.

THE HUMERAL HEAD DEFECT

In general, the greater the defect of the humeral head the more readily recurrence of the dislocation may be expected to occur. With each dislocation the defective area is impinged forcibly against the glenoid rim, and it is likely that the defect becomes deepened with successive dislocations.

RETENTION AFTER REDUCTION

In anterior dislocation, the sling position of adduction and medial rotation is stable, provided the limb is fixed adequately. In assessing stability after posterior dislocation it is helpful to remember the mechanism of the dislocation. In the mechanism of any indirect primary dislocation, and to a less degree the direct form, the humeral head leads through the

capsule, leaving the soft tissues behind it relatively undamaged. If, therefore, the head is replaced to face the opposite direction, the undamaged structures are relatively taut—the first requirement towards stability. In posterior dislocation this position would be lateral rotation. If the arm is also extended at the shoulder the stability becomes so complete that redisplacement cannot be produced with ordinary force. Dislocation would entail distraction of the relatively taut, intact, anterior soft structures (Fig. 2).

This position of stability in posterior dislocation allows the best possible approximation of the stripped labrum and capsule to the margin of the glenoid and the neck of the scapula.

THE SOFT-TISSUE INJURY AND ITS REPAIR

King (1947) believed that there was no essential difference in causation between the single dislocation and the dislocation that becomes recurrent. Watson-Jones (1948) quoted a large series of cases of anterior dislocation adequately retained for four weeks, without the

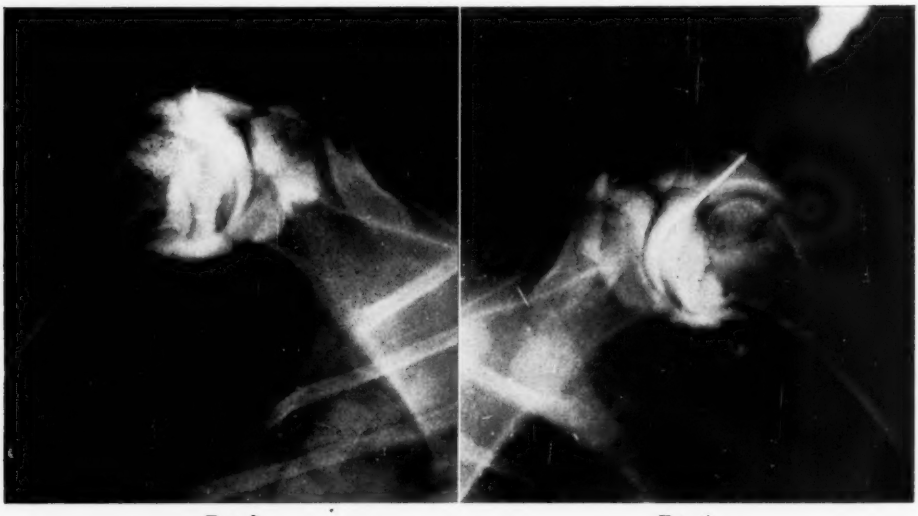


FIG. 3 FIG. 4

Arthrographs of the right shoulder (Fig. 3) and left shoulder (Fig. 4) of a monkey (Macaca mulatta) eight weeks after experimental stripping of the right glenoid labrum from the rim of the glenoid posteriorly and inferiorly. There is no extrusion of the radio-opaque fluid in either shoulder.

complication of recurrence. Perkins (1953), however, restated the doubt about the natural capacity for repair of a detached glenoid labrum. I do not know whether union of the labrum anteriorly has ever been demonstrated after the generally successful Bankart type of repair. Operative repair is still uniformly successful if the labrum is excised. It is desirable to know the natural capacity for repair of a stripped labrum because of the relationship of the capsule to the labrum at the glenoid rim. It may be assumed from the clinical results that stripped capsule is capable of union with subjacent rawed surfaces.

EXPERIMENTAL INVESTIGATION

Thanks to the collaboration of Professor J. Vernon Luck of Los Angeles and Professor Kellogg Speed of Chicago, a study of the reparative capacity of the stripped labrum has been made in a monkey, Macaca mulatta. In both shoulders the posterior aspect of the joint was exposed. On the left side a vertical incision was made in the capsule near the glenoid

labrum, and the labrum was split longitudinally throughout its posterior and inferior aspects. On the right side the capsule was incised at the margin of the attachment of the labrum, which was avulsed from the glenoid posteriorly and inferiorly. After the operation only the muscles and skin were closed.

The length of the rent in the labrum stopped short of allowing the shoulder to dislocate and so avoided the need for post-operative fixation, which is impossible in this animal. The condition produced on the right side simulated a reduced posterior dislocation tear of the capsule and labrum.

Before the animal was killed at eight weeks arthrographs were made of both shoulders. These showed no extra-articular extrusion of the medium (Figs. 3 to 4).

From the specimen shoulders sent by Professor Luck sections were made through the control shoulder (left) and through the site at which the labrum had been avulsed in the right shoulder (Fig. 5). Macroscopically, the previously avulsed glenoid labrum appeared to be firmly reattached to the bone. Histological examination was carried out by Dr Vincent Rudd. In the left shoulder the junction of the glenoid cartilage with the capsule of the joint and the glenoid labrum showed no abnormal feature (Figs. 6 and 7). In the right shoulder this junctional area showed a narrow strand of tissue where cell nuclei were more prominent than in the adjoining tissue. It was not possible to demonstrate any discontinuity of tissue (Figs. 8 and 9).

Comment—It may be reasonably concluded from these observations that the avulsed glenoid labrum does in fact possess a capacity for repair in the monkey, and Professor Joseph Shellshear, who studied the specimens, believed that the analogy would be applicable to man.

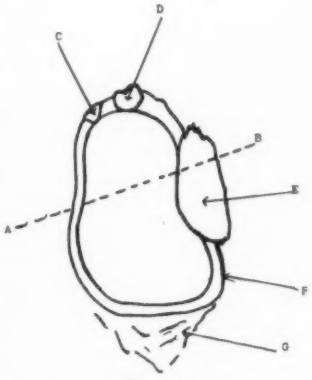


FIG. 5

Diagram of the right glenoid cavity to indicate where the glenoid labrum had been sheared off. A–B, line of cross-section for histological examination. C, tip of coracoid process. D, long head of biceps muscle. E, extent of experimental shearing of the labrum. F, glenoid labrum, separated by a deep cleft from the articular cartilage. G, long head of triceps muscle.

In primary posterior dislocation the position that affords the greatest stability—namely lateral rotation and extension—also favours cicatrisation in the best way to buttress the union at the site of the stripping, just as medial rotation and adduction do after reduction of a primary anterior dislocation. Reasonable repair would not be expected in less than four weeks, with sound repair at six weeks. Watson-Jones (1948) reported one case in which repair of an anterior detachment of the labrum through a superior incision, entailing no anterior scarring, did not prevent recurrence. There would be an adequate buttress in his series of primary anterior dislocations properly retained for four weeks in medial rotation.

Statistical comparison between anterior and posterior dislocations is of little guidance because of the relatively small incidence of posterior dislocation and the fact that reduction is often delayed on account of misdiagnosis.

SUMMARY

1. At an operation for recurrent posterior dislocation of the shoulder observations were made on the mechanism, head defect, method of reduction, and the position of greatest stability.

2. Experimentally, avulsion of the glenoid labrum in a monkey was shown to be capable of sound repair without operation.

3. In the treatment of primary posterior dislocation it is suggested that the position of abduction, lateral rotation and extension is favourable for the approximation of the stripped labrum and capsule to the glenoid rim, and for an effective buttress after cicatrisation.

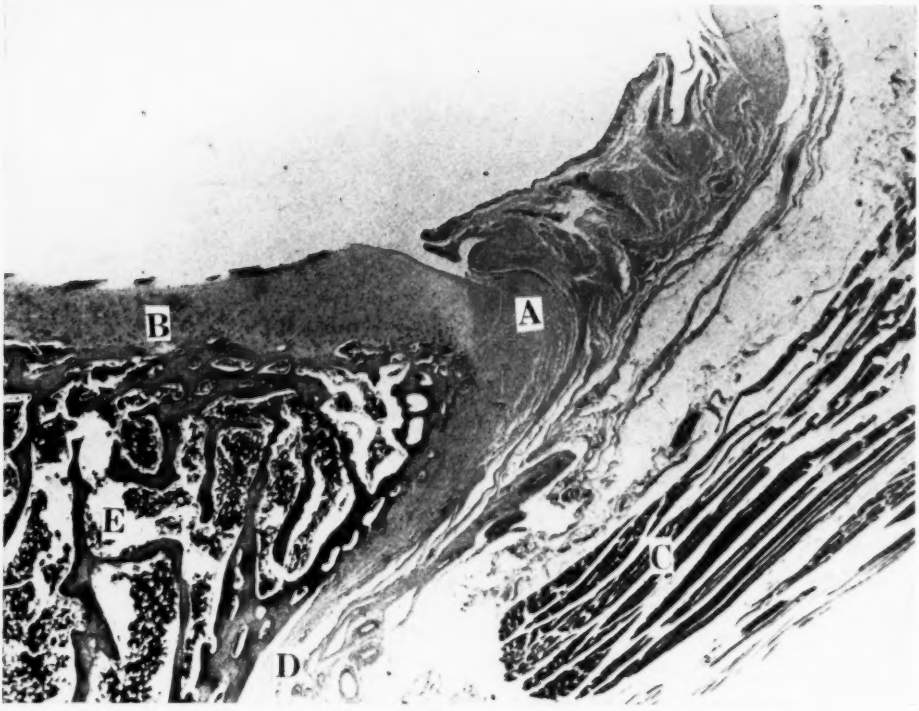


FIG. 6

Section through control (*left*) glenoid cavity. A, junction of glenoid labrum and articular cartilage. B, articular cartilage. C, muscle fibres. D, periosteum. E, bone.

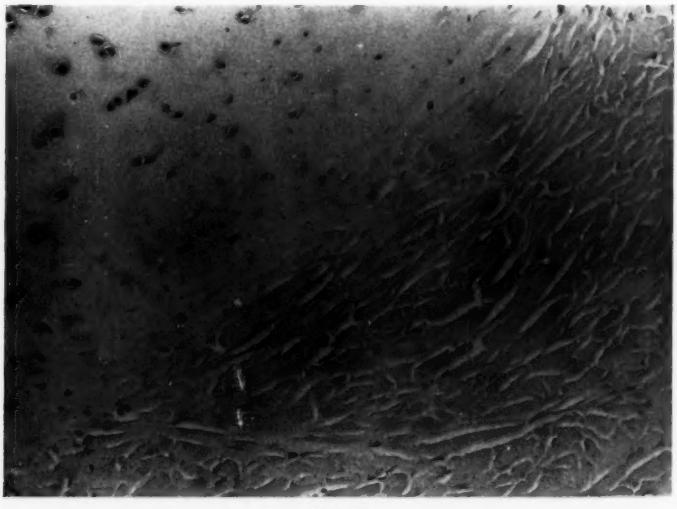


FIG. 7

Left shoulder. High-power photomicrograph of the junction of glenoid labrum and articular cartilage at the line A–B in Figure 5 and at site A in Figure 6.

FIG. 8

Right shoulder. Section through glenoid cavity eight weeks after experimental separation of the glenoid labrum. A, junction of glenoid labrum and articular cartilage. B, articular cartilage. C, muscle. D, periosteum. E, bone.

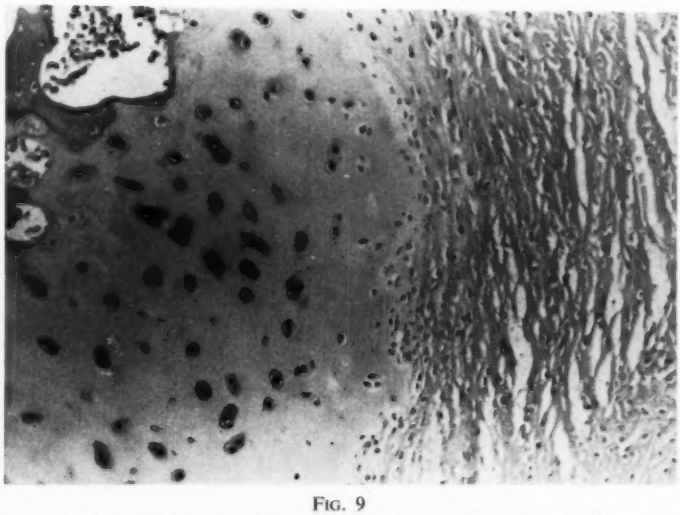


FIG. 9

Right shoulder. High-power photomicrograph of junction of glenoid labrum and articular cartilage at line A–B in Figure 5 and at site A in Figure 8. Note the sound healing at the site of avulsion.

4. If the risk of recurrence is to be reduced to a minimum the shoulder should be retained in the position of greatest stability for at least four weeks, to allow firm union of the avulsed soft tissues.
5. This position for an optimum buttress would also apply after surgical repair for recurrent posterior dislocation.

I am indebted to Professor J. Vernon Luck of the Orthopaedic Faculty, University of Southern California, for performing, on my behalf, the surgical procedure on Macaca mulatta, for the preparation of arthrographs, and the despatch to Sydney of the two shoulders. I thank the late Professor Kellogg Speed, of Chicago, for his liaison and assisting at operation on the Macaca mulatta; Professor J. L. Shellshear, Sydney, for his dissection of the shoulders; Professor F. R. Magarey, Sydney University, for preparation of the microscopical slides; Dr Vincent Rudd for his interpretation of these slides; and Dr P. K. Lamond and the Department of Medical Illustration, St Vincent's Hospital, Sydney, for the photographic reproductions.

REFERENCES

HENDERSON, M. S. (1921): Habitual or Recurrent Dislocation of the Shoulder. Surgery, Gynecology and Obstetrics, **33,** 1.

KING, T. (1947): Recurrent Dislocation of the Shoulder. Medical Journal of Australia, **i,** 697.

MCLAUCHLIN, H. L. (1952): Posterior Dislocation of the Shoulder. Journal of Bone and Joint Surgery, **34–A,** 584.

PERKINS, G. (1953): Rest and Movement. Journal of Bone and Joint Surgery, **35–B, 521.**

WATSON-JONES, Sir R. (1948): Recurrent Dislocation of the Shoulder. Journal of Bone and Joint Surgery, **30–B,** 6.

EXCISION OF THE COCCYX FOR COCCYDYNIA

A Study of the Results in Twenty-eight Cases

J. B. PYPER, BELFAST, NORTHERN IRELAND

From the Musgrave Park Hospital, Belfast

Pain in the region of the coccyx is a condition in which " at present there is wide divergence of opinion concerning the best form of treatment " (Key 1937). In particular, there is no general agreement about the effectiveness of excision of the coccyx in relieving the symptoms. Most surgeons appear to be dissatisfied with the results of this operation. Edwards (1938) stated that there is " more or less continuous disagreement " about the effectiveness or otherwise of operation, and concluded that " because of the frequent failure of excision to effect a cure, conservative measures should be persisted with for longer periods than is generally the practice."

In order to obtain further evidence on this point a study has been made of the results of operation over a ten-year period.

MATERIAL AND METHOD OF STUDY

Records of the thirty-four patients subjected to excision of the coccyx for coccydynia from 1947–56 were obtained from the Musgrave Park Orthopaedic Hospital, Belfast, and from the Orthopaedic Departments of the Royal Victoria and Belfast City Hospitals. Of these thirty-four patients twenty-one attended for review and seven replied to a postal enquiry. The results of twenty-eight operations were thus available for study.

Each patient was asked to choose from a list of five categories of result (Table I) his own estimate of the effect of the operation upon the coccygeal pain. The patients were also asked whether they had suffered low-back pain with the coccygeal pain, whether they recalled any injury related to the onset of symptoms, how long the symptoms had been present before operation, and how long after operation most benefit was obtained. They were also asked about previous conservative treatment. The available notes of the pre-operative physical and radiographic examination were studied.

TABLE I

FIVE CATEGORIES OF RESULT SUBMITTED FOR PATIENT'S OWN ASSESSMENT OF EFFECT OF OPERATION

Complete relief
Marked improvement
Slight improvement
No relief
Worse than before

ANALYSIS OF RESULTS

The total series of thirty-four patients comprised twenty-nine women and five men, aged from eighteen to sixty (average thirty-five) years.

The time since operation, in the twenty-eight patients traced, varied from four months to ten years, with an average of three and a half years.

By asking the patients each to select his or her individual result from the alternatives shown in Table I it was expected that the results could be studied in five groups. No patient, however, selected either " slight improvement " or " worse than before " as the appropriate description. The results, therefore, fall into three groups and the number of patients in each group is shown in Table II.

In the twenty-five patients comprising groups 1 and 2 fullest relief of symptoms was experienced at a period after operation which varied from six weeks to eighteen months (average 4·2 months).

In an attempt to determine whether there was any significant correlation between the various factors involved (Table III) and the result of operation, several possible determinants were studied.

TABLE II

ANALYSIS OF RESULTS (TWENTY-EIGHT CASES)

Group	Result	Number	Per cent
1	Complete relief .	13	46
2	Marked improvement	12	43
3	No relief . . .	3	11
	Total . .	28	100

TABLE III

INCIDENCE OF RELEVANT FACTORS

	Group 1	Group 2	Group 3
History of injury . . .	46%	50%	66%
Lumbar backache . . .	46%	50%	33%
Conservative treatment tried .	31%	33%	33%
Average duration of symptoms, in months, before operation .	25	29	67

History of injury—A definite history of injury in association with the onset of symptoms was described by six of the thirteen patients in group 1, six of the twelve patients in group 2, and two of the three patients in group 3. In most cases this injury was external—a fall on the seat or a direct blow over the coccyx. One patient in group 1 and one patient in group 2 blamed a difficult confinement for the onset of the complaint.

Associated lumbar pain—Lumbar pain was present with coccydynia before operation in six patients in each of groups 1 and 2 and one patient in group 3. In no case did removal of the coccyx relieve the lumbar backache, and in three cases lumbar aching was experienced for the first time after the operation.

Failed conservative treatment—Conservative treatment, mainly by manipulation and injection of local analgesics, but also including various forms of physiotherapy, had been tried without success in almost a third of the patients operated upon, and in about the same proportion in each group.

Duration of symptoms before operation—This varied from four months to ten years and tended to be longer in the less successful groups.

Tenderness—In all patients the coccyx was reported to be tender on rectal examination either on pressure or on movement.

Radiographic changes—Many variations were noted in the patients who were radiographed before operation. In some the coccyx appeared as a single bone; in others three or more segments were visible. In some there was irregularity of the sacro-coccygeal joint. The coccyx was acutely anteflexed in four; in only one case was it considered to have been broken. The numbers showing any one of these variations were insufficient to allow any reliable conclusions to be drawn.

Other factors—For the whole group the average time spent in hospital after operation was three weeks. Only one patient developed any complication: this was a persistent sinus in the region of the wound which was cured, four months after operation, by curettage of the wound, removal of non-absorbable buried sutures, and re-suture. The result in this case fell into group 2.

TABLE IV

RESULTS OF EXCISION OF THE COCCYX, MODIFIED FROM EDWARDS (1938) AND INCLUDING PRESENT FIGURES FOR COMPARISON

Author	Cases	Traced	Cured	Improved	Unimproved	Per cent unimproved
Duncan .	30	30	22	3	5	17
Hansa .	49	49	40	0	9	18·4
Key . .	15	14	12	2	0	0
Edwards .	37	16	8	6	2	12·5
					Average:	11·9
Present series	34	28	13	12	3	10·7

DISCUSSION

Coccydynia is a subjective complaint, and it is reasonable therefore to assess the results of treatment on a subjective basis; indeed this seems to be the only possible method. Not only is it necessary to depend on the patients' assessment of the results of operation, one is similarly limited in deciding, in the first place, that operation is indicated. This study suggests that there is no constant factor in the history, no reliable physical sign, and no specific radiographic change that can be regarded as a definite pointer in advising operation. If we consider the results simply in two groups, " improved " and " unimproved," the latter contains such a small number (three) of patients that percentages are meaningless. On the other hand there is no one factor present in more than 50 per cent of the improved group. That is to say neither injury nor the lack of it, nor the previous use of conservative treatment, nor the presence (or absence) of lumbar backache is a preponderant factor among patients treated successfully by operation. That the length of history is longer in the least successful group is because this very small group happens to include one patient with a ten-year history. These conclusions agree fairly closely with the experience of previous observers.

Edwards (1938) placed no reliance on the exact site of pain or tenderness, on fixity or mobility of the coccyx, or on its radiographic appearance. Moreover he quoted Duncan who made a radiological study of 200 patients and could not demonstrate any constant difference

between normal and painful coccyges. Nor could Key (1937) find any correlation between radiographic appearance and the later operative result. From these reports it appears to be agreed that it is impossible to select patients for operation on the basis of events in the history or findings on examination, although Key considered failure of conservative treatment an indication for operation. The authors differ, however, in their conclusions regarding the effectiveness of operation. Key, claiming improvement in all of fourteen cases, concluded that " excision and careful restoration of the pelvic floor may be expected to relieve symptoms and cause no disability." He maintained that good results depend not so much on any method of selection of patients as on meticulous operative technique. Edwards reported two failures out of sixteen operations, and regarded this failure rate as a strong argument for persisting with conservative measures. As well as his own figures and those of Key, already mentioned, he quoted the results of Hansa and of Duncan (Table IV). Nixon (1939) declared that operation gave good results in 85 per cent of patients as compared with 62 per cent of good results in patients treated conservatively.

The results tabled by Edwards were expressed as " per cent of patients unimproved." The average in this category for the four sets of figures quoted was 11·9. The corresponding figure in the present series is 10·7—a very close parallel.

My own observations agree with those of previous authors, except that failure of conservative treatment does not appear to be a pre-requisite in recommending operation as this factor was present in only 32 per cent of the " cured or improved " group in my series.

The difference of opinion regarding the effectiveness of operation appears to lie not so much in the actual figures as in their interpretation. But if we accept a rate of 11 per cent as the average number of patients unimproved after operation this implies a worthwhile result in almost 90 per cent—surely a very satisfactory figure.

One other interesting point emerges. Of the three patients who gained no relief from operation two had, at the time of review, been referred for a psychiatric opinion because of numerous widespread aches and pains without demonstrable organic basis. The report on one of these patients was that she was " suffering from a severe neurotic depression with marked suicidal tendencies." The third patient, though not seen by a psychiatrist, was regarded by an independent observer as " grossly hypochondriacal with a great tendency to exaggerate her symptoms." Were it possible to exclude this type of patient I believe the figure of 90 per cent " cured or improved " could be bettered. As it is, the present study suggests that the number of " psychoneurotic coccydynias " that reach the operating table is small, and it seems clear that " the functional and psychological aspect of coccydynia has been exaggerated " (Watson-Jones 1943).

Finally it should be made clear that this review is not intended to be a comprehensive study of coccydynia or of the various forms of treatment that have been used in this condition. It merely sets out to answer the specific question: " is coccygectomy any good? " Judging from the enthusiastic and grateful replies received from many patients, and from the fact that almost 90 per cent of them have gained worthwhile benefit from the operation, it seems clear that the question can be answered in the affirmative.

SUMMARY

1. Twenty-eight patients subjected to excision of the coccyx for coccygeal pain during the last ten years have been reviewed.

2. No constant means of selection appears to have been used in recommending these patients for operation, and, in retrospect, no factor in the history or examination emerges as reliable for making such selection in the future.

3. Operation may be recommended as likely to provide a cure in about 45 per cent and to give worthwhile relief in another 45 per cent of cases.

4. When conservative treatment has succeeded, operation will not, of course, be required, but failure of conservative treatment is not an essential pre-requisite in recommending operation.
5. If more care were taken to eliminate the markedly psychoneurotic patients the worthwhile results of operation could probably be increased even above 90 per cent.
6. Excision of the coccyx is certainly a useful operation and should not be discarded.

I should like to thank all the surgeons in charge of the departments concerned for permission to study their patients, and the nursing and clerical staff, particularly the clerical staff of Musgrave Park Hospital, for valuable assistance.

REFERENCES

EDWARDS, M. (1938): Trauma of the Coccyx and Coccygodynia. American Journal of Surgery, **N.S. 42,** 591.
KEY, J. A. (1937): Operative Treatment of Coccygodynia. Journal of Bone and Joint Surgery, **19,** 759.
NIXON, E. A. (1939): Coccygodynia. American Journal of Surgery, **N.S. 44,** 390.
WATSON-JONES, Sir R. (1943): Fractures and Joint Injuries. Third edition. Vol. I, p. 382. Edinburgh: E. & S. Livingstone Ltd.

LONGITUDINAL OSTEOTOMY OF THE TIBIA

(The " Reed " Osteotomy)

O. R. NICHOLSON, AUCKLAND, NEW ZEALAND

From the Institute of Orthopaedics, Royal National Orthopaedic Hospital, London

Many methods of osteotomy have been described for the correction of torsional deformities of the tibia. The method of longitudinal osteotomy described by Haas (1929) is not widely known and has not been subsequently reviewed. Haas described three cases in which the operation had been performed; two operations were on the tibia and one on the femur. Its use for the correction of femoral torsion was described in the first edition of Campbell's *Operative Orthopedics* (1939), but the description was omitted from subsequent editions. The method was introduced to the Royal National Orthopaedic Hospital in 1930 by Mr H. J. Seddon, who had seen the operation performed in the United States of America. It has since been used with satisfactory results as the routine method of correcting tibial torsion and minor degrees of associated angular deformity.

The method, to quote Haas, " depends on the principle that if a series of longitudinal osteotomies are made about the circumference of a bone, they will so weaken the structure that it will yield in any direction to bending or twisting forces and still maintain the continuity of the bone." In the original description multiple longitudinal cuts (five or six) were made with an osteotome through both cortices of the upper tibia to allow correction of both lateral deviation and rotation of the tibia.

TECHNIQUE OF OPERATION

The proximal half of the tibial shaft is exposed through an incision over the subcutaneous surface and the periosteum is reflected over a length of about four inches.

Longitudinal saw cuts about an eighth of an inch apart are made with a motor saw, care being taken that the blade is kept cool with saline. In this way approximately two-thirds of the circumference of the tibia is converted into strips like reeds. The residual bridge posteriorly is then divided transversely at about its middle with an osteotome or with a Gigli saw (Fig. 1).

When a twisting force is applied the individual " reeds " rotate and the deformity is corrected. On occasions, however, particularly in older patients, there may be some resistance to rotation and this may be overcome by dividing alternate " reeds " transversely at their proximal and distal ends, thus leaving interdigitating strips (Fig. 2). Fracture of some of the " reeds " may occur during the manipulation without impairing stability. It is seldom necessary to divide the fibula. The position after manipulation in a case in which division of the " reeds " was not necessary is shown in a radiograph (Fig. 3).

The wound is closed and the limb is immobilised in an above-knee plaster in a slightly over-corrected position and with the knee flexed at least 30 degrees to maintain position.

The plaster is changed after two weeks, when the position may be adjusted. If there is an associated valgus or varus deformity the second plaster must be applied with the knee extended. Immobilisation is continued until the bone has united.

RESULTS

Records are available of thirty-eight operations carried out on thirty patients. The conditions for which these operations were performed and the results are summarised in Table I. In one patient the method was used as part of the procedure described by van Nes

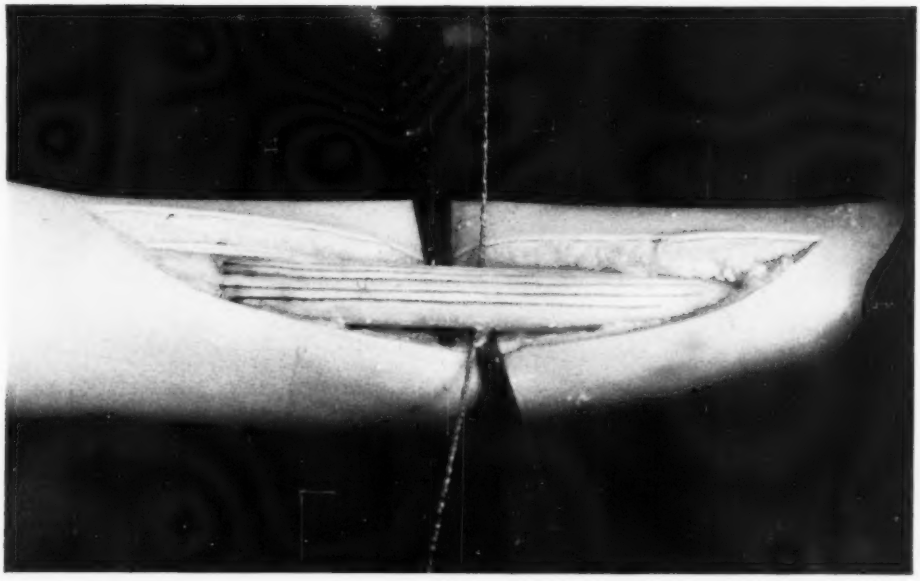


FIG. 1

Multiple longitudinal saw cuts have been made and the posterior cortex is being divided transversely with a Gigli saw. It is usually possible then to correct the deformity by manipulation.

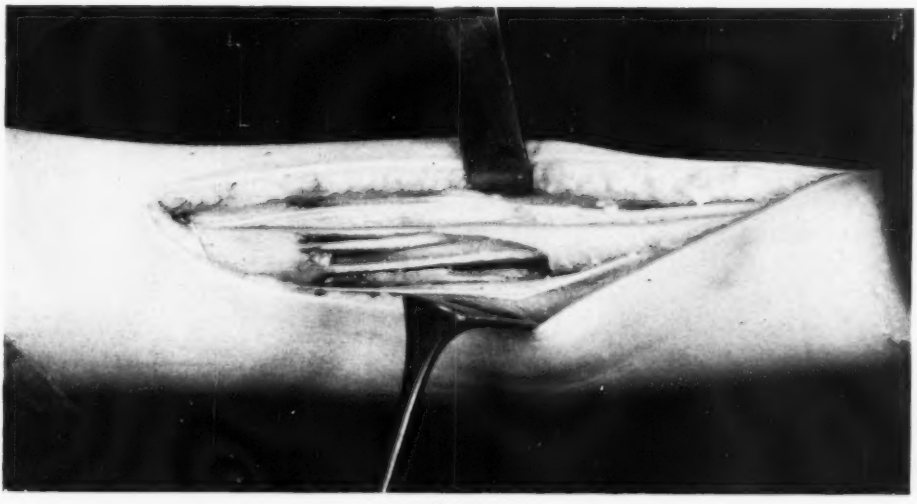


FIG. 2

Final position after division of alternate reeds at their proximal and distal ends. The rotational correction obtained in this case was about 60 degrees.

(1950) and 100 degrees of rotation were obtained. A partial relapse occurred in this case and the operation was repeated five years later.

Union was generally complete in eight to twelve weeks, when the clinical correction was always satisfactory.

FIG. 3
Radiograph showing position at the end of the operation. In this case division of the " reeds " was not necessary.

COMPLICATIONS

Vascular and nervous complications have not occurred in this series.

Non-union occurred in three patients, all young adults (Table I). The only cause that can be suggested for the failures is that in adults the extensive periosteal stripping seriously interferes with the blood supply to the bone. It therefore seems preferable to reserve this method for patients under the age of twenty years.

Fracture occurred in one patient six months after operation and three months after removal of the plaster, but the fracture was undisplaced and united after a further period of immobilisation.

TABLE I

SUMMARY OF THIRTY-EIGHT OPERATIONS

Diagnosis	Number of Patients	Number of Operations	Age range in years	Complications
Poliomyelitis	11	11	6–25	Non-union in one case (patient aged 25 years). Treated by bone grafting
Congenital talipes equinovarus	8	13	2–11	
Congenital tibial torsion	2	2	5–22	Non-union in one case (patient aged 22 years)
Tuberculosis of hip / Osteomyelitis of femur (deformity developed during prolonged immobilisation on frame)	3	3	6–25	Non-union in one case (patient aged 25 years). Treated by bone grafting
Still's disease	2	2	9–16	
Rickets	2	3	6–7	
Congenital absence of proximal part of femur	1	2	9–14	Operation performed as part of van Nes procedure, and repeated
Post-meningitic paresis	1	2	5	

ADVANTAGES OF THE METHOD

Since no internal fixation is required the position of the leg may be adjusted when the first plaster is changed.

A poorly developed bone is not weakened by this operation as it is by the removal of a wedge of bone as in the O'Donoghue (1940) method. If the deformity recurs the operation may be repeated, as was successfully done in one patient in this series.

SUMMARY

1. "Reed" osteotomy has proved a satisfactory method for the correction of torsional deformity of the tibia and of associated minor varus or valgus deformity.
2. It is an "osteotomy in continuity" and maintains stability of the bone.
3. The position of the limb may be adjusted at the first change of plaster.
4. Three cases of non-union occurred in thirty-eight operations.
5. The operation should not be done on adults. Perhaps it may be wise to reserve it for even younger patients because its success depends on the pliability of cortical bone, which rapidly diminishes with increasing age.

I wish to thank the staff of the Royal National Orthopaedic Hospital, and Mr H. J. Seddon in particular, for permission to publish this report of cases treated by them. I am indebted to Mr R. J. Whitley, F.R.P.S., of the Clinical Photographic Department, Institute of Orthopaedics, for the photographs.

REFERENCES

CAMPBELL, W. C. (1939): Operative Orthopedics. London: Henry Kimpton.
HAAS, S. L. (1929): Longitudinal Osteotomy. Journal of the American Medical Association, **92,** 1656.
NES, C. P. VAN (1950): Rotation-plasty for Congenital Defects of the Femur. Journal of Bone and Joint Surgery, **32-B,** 12.
O'DONOGHUE, D. H. (1940): Controlled Rotation Osteotomy of the Tibia. Southern Medical Journal, **33,** 1145.
SEDDON, H. J. (1956): Personal communication.

FRACTURE-DISLOCATION OF THE LUMBAR SPINE

Report of an Unusual Case

D. E. ROBERTSON, GALASHIELS, SCOTLAND

From the Peel Hospital, Galashiels, Selkirkshire, Scotland

The usual deformity encountered in fracture-dislocation of the lumbar spine is forward displacement of one vertebral body upon another. This note records a case of traumatic backward displacement, a condition that does not appear to have been reported before. Backward displacement does occur, however, in the late stages of degeneration of an intervertebral disc (Fig. 1).

FIG. 1
Posterior displacement of the fifth lumbar vertebra on the sacrum.

CASE REPORT

The patient, a well-built man of forty-eight years, was attempting to close the rear door of a cattle truck by pushing up the ramp. Wearing rubber boots, he was standing in a muddy farmyard with his arms outstretched above his head when he slipped, and fell forwards into a crouched position on one knee. As the ramp fell he was struck in the upper lumbar region by its edge and suffered immediate acute pain in the back at the level of the thoraco-lumbar junction. He was able, nevertheless, to get up and to drive his truck a few miles home. On examination three hours later there were swelling and tenderness in the thoraco-lumbar region. Radiographs showed backward displacement of the second on the third lumbar vertebra with slight wedge deformity of the twelfth thoracic and first lumbar vertebrae (Fig. 2). Lateral wedging of the

FIG. 2

Early lateral radiograph showing the posterior displacement of the second lumbar vertebra on the third. There was slight wedging of the twelfth thoracic and first lumbar vertebrae.

FIG. 3 FIG. 4

Right and left oblique radiographs showing widening of the facet joints between the second and third lumbar vertebrae.

FIG. 5

Lateral radiograph thirteen months after the injury. Narrowing of the disc space between the second and third lumbar vertebrae with increased posterior displacement of L.2.

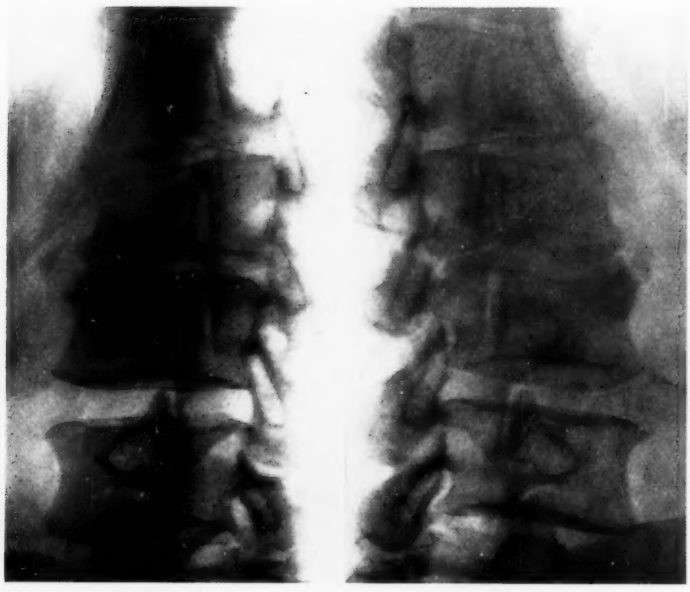


FIG. 6 FIG. 7

Right and left oblique radiographs thirteen months after the injury, showing persistent widening of the facet joints, though to a less marked degree.

second lumbar vertebra with a fracture of the transverse process of the third lumbar vertebra on the right side were seen in the antero-posterior radiograph. Oblique views (Figs. 3 and 4) showed widening of the intervertebral joints between the second and third lumbar vertebrae. There was a probable fracture of the pars interarticularis of the third lumbar vertebra.

He was treated by rest in bed for four weeks and then allowed up in a plaster jacket which was replaced by a Taylor brace after eight weeks. During treatment there was evidence of nerve root irritation in the form of pain on coughing and sneezing referred to the front of the right thigh; but there were no abnormal neurological signs in either limb. He resumed work five months after the injury. Radiographs thirteen months later showed marked diminution of the intervertebral disc space between the second and third lumbar vertebrae (Fig. 5). There was still widening of the interfacetal joints between these two vertebrae (Figs. 6 and 7).

COMMENT

The peculiar feature of this case is the diastasis between the intervertebral joints, greater on one side than on the other, well demonstrated in the oblique radiographs. The diastasis has persisted. From this appearance, and from the slight lateral wedging of the second lumbar vertebra, it might be argued that the spine is unstable; but the patient has been working in a heavy occupation for the past two years without complaint. A recent radiograph shows a gradual reduction in the disc space between the second and third lumbar vertebrae, with an apparent increase of the backward displacement such as is associated with the more common variety referred to in Figure 1.

My thanks are due to Mr I. S. Smillie for his help and criticism, to Mr I. S. Sutherland, who kindly lent me the radiograph shown in Figure 1, and to Dr W. Cockburn, radiologist.

RADIAL NERVE IN OSSEOUS TUNNEL AT HUMERAL FRACTURE SITE DIAGNOSED RADIOGRAPHICALLY

H. L. DUTHIE, GLASGOW, SCOTLAND

From the Western Infirmary, Glasgow

When a fracture of the shaft of the humerus causes a lesion in continuity of the radial nerve the latter may be involved to varying degrees in the healing process at the fracture site. Seddon (1947) mentioned tethering to the scar and adherence to the osteoid tissue. This case is remarkable in that the extent of involvement was shown by radiographic examination.

CASE REPORT

A boy of fifteen fell from a tree sustaining an oblique closed fracture of the shaft of the left humerus at the junction of its middle and distal thirds, and also a slight displacement of the distal epiphysis of the left radius. A wrist drop was recorded but no sensory observations are available. Six months later the fractures were soundly healed but there was no nerve recovery.

FIG. 1
Healed fracture of the humeral shaft with tunnel transmitting the radial nerve.

When first seen at this hospital eight and a half months after the injury he had a radial nerve palsy from the branch to brachioradialis distally, but no sensory loss was detected. The joints were fully mobile.

Radiographs showed sound healing and good remodelling of the humerus at the site of fracture with the foramen in the lateral part of the shaft at this point coinciding with the distal part of the spiral groove (Fig. 1). These appearances, together with persistence of the radial palsy, suggested that the foramen marked the path of the nerve through a newly formed osseous tunnel in the humerus at the site of union.

At operation this was confirmed; the radial nerve was found to pass obliquely through the bone for about three centimetres from the distal end of the spiral groove. A neuroma at the point of entry was excised. The intra-osseous part was left *in situ* and the nerve was repaired after mobilisation.

Motor function is recovering satisfactorily from brachioradialis distally.

COMMENT

The patient presented a radial palsy of eight and a half months' standing after a closed fracture of the humeral shaft. Only about one in five of such injuries leads to complete rupture of the nerve (Seddon 1947). Further, the foramen was the only defect in an otherwise perfectly healed fracture. Probably the bone had united about the nerve interposed between its ends and pressure had prevented regeneration. Exploration showed the nerve to be in continuity through the bone.

I wish to thank Mr A. R. Parkes for permission to publish this case and for his criticism and advice.

REFERENCE

SEDDON, H. J. (1947): Nerve Lesions Complicating Certain Closed Bone Injuries. Journal of the American Medical Association, **135,** 691.

FORAMEN IN THE HUMERUS CAUSED BY THE MEDIAN NERVE

ROBERT ROAF, OSWESTRY, ENGLAND

In January 1954 a boy of sixteen consulted me complaining of pain and weakness in his left hand. A dislocation of the elbow with displacement of the medial epicondyle, sustained in 1949, had been treated at another hospital, whose notes made no mention of any nerve lesion; the original radiographs were not available.

Examination revealed a complete median nerve lesion. Radiographs showed some alteration in the shape of the lower end of the humerus, particularly the trochlea, and a foramen on the medial border of the bone just over an inch above the lower end (Fig. 1).

FIG. 1
Radiograph showing the foramen through the lower end of the humerus.

As it was uncertain how long the median nerve lesion had been present, exploration was offered. At operation the nerve was found to be normal as far as the foramen in the bone. Through this it passed from front to back, continuing distally to end in a large neuroma adherent to the back of the capsule of the elbow. The part of the nerve between the foramen and the neuroma looked and felt normal. The distal end of the median nerve was now exposed in the forearm and was traced proximally, being found to end in a neuroma stuck to the front of the elbow joint. The nerve ends were freed and the neuromata were excised. There was extensive degeneration of the nerve fibres; and, by the time the abnormal tissue had been resected, there was a large gap between the nerve ends, which precluded suture. Figure 2 depicts the operation findings. The opposite elbow was normal on radiographic examination.

The operation findings were interpreted thus. At the time of the original injury the nerve must have been trapped in the elbow joint and also came to lie between the medial epicondyle and the rest of the humerus. In the course of time the medial epicondyle had joined to the

FIG. 2
Drawing of the conditions found at operation.

rest of the humerus, but the foramen had remained where the median nerve passed between the bone ends. It is uncertain whether the median nerve had been torn at the time of the original injury or whether continued pressure between the trochlea and the olecranon had divided it.

VARIATIONS IN JOINT SPACE OF THE HIP AS SHOWN RADIOGRAPHICALLY

G. P. ARDEN, WINDSOR, ENGLAND

From the Heatherwood Orthopaedic Hospital, Ascot

Several authorities have asserted that the joint space of an osteoarthritic joint will improve after surgical treatment.

Wardle (1955) stated that if the correct realignment is achieved after a McMurray's osteotomy one notices in the radiographs a reappearance of the joint space previously obliterated in arthritic patients. This tendency of the bone and articular cartilage in the femoral head to return towards normal after a successful osteotomy suggests a profound metabolic change, as noted by McFarland in 1954. Osborne and Fahrni (1950) found examples of partial restoration of the joint space after McMurray's osteotomy, in which the articular surfaces had become more clearly defined and regular in outline.

FIG. 1

Initial radiographs, showing osteoarthritis of both hips, with absent joint space.

It seems more probable that an apparent improvement in the joint space is due to a faulty radiographic technique, and it is therefore important to have correct and standardised views before assuming that any improvement is real.

CASE REPORT

A man, aged seventy-seven, with pain in both hips for three years was seen in June 1949 and again seven years later. He was able to walk 100 yards with sticks, but had no severe pain at night. On examination both hips showed considerable limitation of movement: on

both sides flexion was through about 70 degrees; abduction and adduction were each through 10 degrees; and rotation was almost nil.

The radiographs taken at the second examination showed osteoarthritis of both hips; and, when these were compared with radiographs taken in 1949, there appeared to have been a remarkable improvement in the joint space on the right side although the patient had had

FIG. 2

FIG. 3

Figure 2—Right hip seven years later, the patient having had no treatment. There seems to have been a remarkable reformation of the joint space. Figure 3—Five months later still. This radiograph, taken 10 degrees off the vertical, shows once again no joint space on the right side.

no treatment during the intervening years. A further radiograph, however, taken five months later with a slightly less vertical view, showed that the joint space had disappeared again, and the appearance was now like that in 1949.

REFERENCES

McFARLAND, B. (1954): My Present Attitude to Osteo-arthritis of the Hip. Journal of Bone and Joint Surgery, **36–A,** 476.

OSBORNE, G. V., and FAHRNI, W. H. (1950): Oblique Displacement Osteotomy for Osteoarthritis of the Hip Joint. Journal of Bone and Joint Surgery, **32–B,** 148.

WARDLE, E. N. (1955): Displacement Osteotomy of the Upper End of the Femur. Journal of Bone and Joint Surgery, **37–B,** 568.

OLIGODACTYLY

MEREDITH VAUGHAN JONES, PORT DINORWIC, NORTH WALES

From the Royal Southern Hospital, Liverpool

Although congenital anomalies of the hand are as common as they are varied, oligodactyly is relatively rare. It is regarded as a real aberration and not a reversal to type, because all our mammalian ancestors are said to have been pentadactylous. As a rule in cases of oligodactyly the radius or ulna is deficient or absent and there is a club hand appropriate to the deficiency. It has been said that the condition is usually familial. In the present instance

FIG. 1
Photographs of the hand.

there was " no family history," but this is probably not of much significance and the case is presented rather from the point of view of its intrinsic interest as a rare type of congenital deformity.

The patient, an old lady of eighty-six years, was admitted to hospital on account of a left hemiplegia. Early progress was satisfactory but at the end of nine weeks she suddenly collapsed and died. The deformity of the right hand had nothing to do with her terminal illness. It had been present from birth and she had no other deformity.

The right hand consisted of a thumb and two digits, all three of normal appearance (Fig. 1). The metacarpals corresponding to the absent digits were also absent, and the palm of the hand was correspondingly narrow. She had not undergone any surgical operation. She wrote with this hand and she carried out all her domestic duties. The movements of

the thumb and the two fingers were normal. Sensation was normal, and the grip was of average strength (the hemiplegia prevented valid comparison with the left hand). The radial pulse was palpable in the usual position, the circulation of the hand appeared good, and the condition of the skin was normal.

Radiographs of the right hand (Fig. 2) and wrist showed that the three metacarpals and phalanges were normal. All the carpal bones were present, but the lunate and triquetral bones were fused and the shape of the individual carpal bones was unusual though not grossly so. The first metacarpal articulated with the trapezium, the second with the trapezium and capitate, and the third with the hamate. The trapezoid was small. It was situated posteriorly and was not apparently articulating with the adjacent metacarpal though close to it. Comparing the bones present in the right hand with those of the left, the right trapezium

FIG. 2
Radiograph of the wrist and hand.

FIG. 3
Post-mortem arteriograph.

was the smaller, whereas the two right finger metacarpals were larger than those of the normal hand. The radius and ulna appeared normal.

After death arteriographs were taken of the right forearm (Fig. 3). The ulnar and radial arteries were shown to be normal. Their terminations were as follows.

Radial artery—At the base of the first metacarpal the radial artery gave off a small branch which passed along the radial side of the thumb. The main branch of the artery crossed the base of the first metacarpal to its ulnar side, and, after giving off a small branch across the base of the second metacarpal which anastomosed with the ulnar artery, it passed distally along the ulnar side of the first metacarpal and divided at its distal end. The main branch at this division passed along the ulnar side of the thumb, and the other much smaller branch along the radial side of the first finger.

Ulnar artery—At the base of the third metacarpal the ulnar artery divided into a large and a small branch. The latter passed distally on the ulnar side of the third metacarpal; the larger branch crossed to the radial side of the base of this metacarpal and passed distally between it and the second. At this point it gave off a small branch which crossed the base of the second metacarpal and anastomosed with the radial artery. The main branch continued to the level of the metacarpo-phalangeal joints and then divided into a digital artery on the radial side of the second finger and a similar artery on the ulnar side of the first finger.

DISCUSSION

It is of interest that the ulna and radius were normal. Articulations at the wrist suggest that the metacarpals were the first, third and fourth. This hand would therefore combine a central and marginal oligodactyly. Presumably the metacarpals were called upon to transmit a little more stress than those of the normal hand, and this would explain why they were slightly larger than normal. The arteriograph shows the presence of a palmar arch, and the picture of the arterial arrangement generally suggests ablation of part of a normal pattern rather than a primary rearrangement of vessels. The small size of the vessels on the radial side of the first digit and the ulnar side of the second suggests that they may have suffered from whatever factor it was that caused suppression or absence of the second and fifth metacarpals and phalanges.

SUMMARY

The skeletal and arterial changes in a somewhat unusual case of oligodactyly are described.

AN ADAPTOR FOR EXTRACTING McLAUGHLIN NAILS

J. N. ASTON, LONDON, ENGLAND

From the Orthopaedic Department, St Bartholomew's Hospital, London

Extractors for nails used in pinning fractures of the cervical and trochanteric regions of the femur are expensive, but an essential part of the operator's equipment.

A small adaptor is illustrated which may be screwed on to the end of a McLaughlin nail so that it can be removed by extractors designed for the Watson-Jones nail, used in

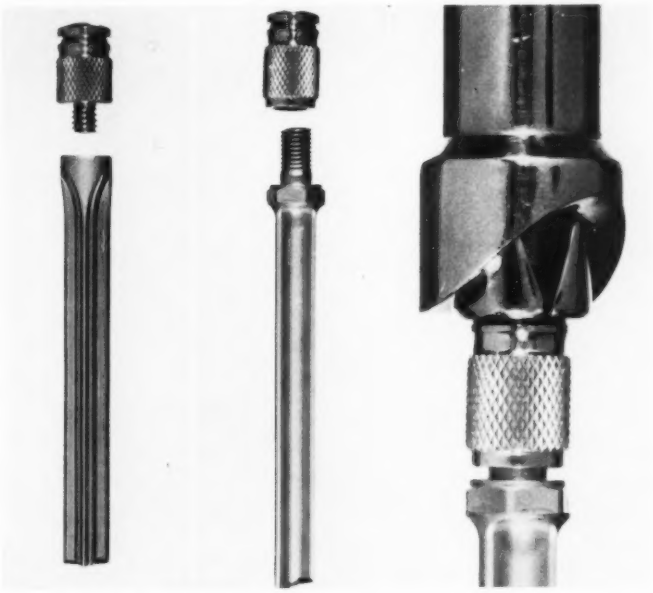


FIG. 1 FIG. 2 FIG. 3

treating simple femoral neck fractures. The adaptor has a head resembling that of a Watson-Jones nail and can be of two kinds: one for the original three-flanged McLaughlin nail, in which a bolt is used to secure the plate to the nail (Fig. 1); and the other for the newer four-flanged nail in which the plate is secured by a nut (Fig. 2).

Figure 3 shows the head of the adaptor screwed to a four-flanged nail, and gripped by the standard Watson-Jones nail extractor.

The adaptors have been made by the London Splint Company, 67–69 Weymouth Street, London, W.1. I am indebted to Mr N. K. Harrison and the Department of Medical Photography, St Bartholomew's Hospital, for the illustrations.

A SIMPLE TRACTION HARNESS FOR CERVICAL MANIPULATION

J. N. WILSON, STANMORE, ENGLAND

From the Institute of Orthopaedics, Royal National Orthopaedic Hospital, London and Stanmore

The acute cervical disc syndrome, with or without torticollis, can often be improved dramatically by a rotatory manipulation under traction, without anaesthetic. Difficulty is always encountered during this procedure, especially in a patient with a thick neck, because

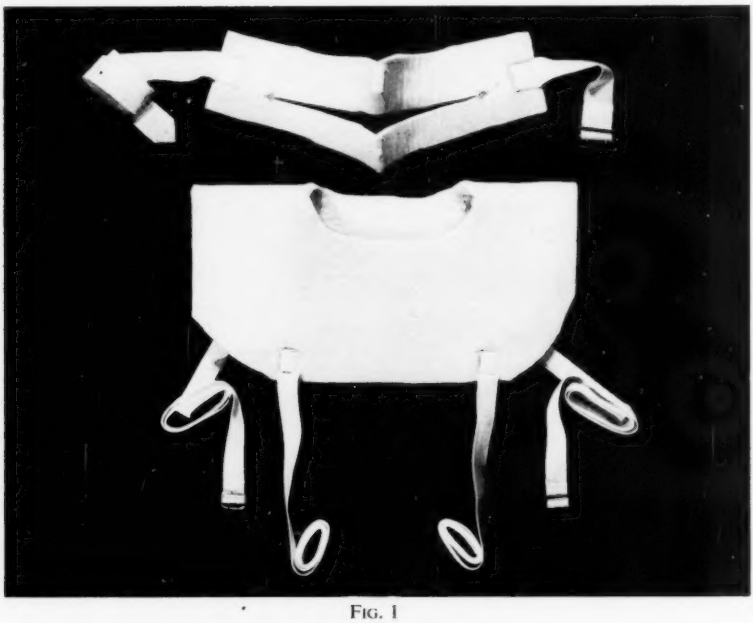


FIG. 1

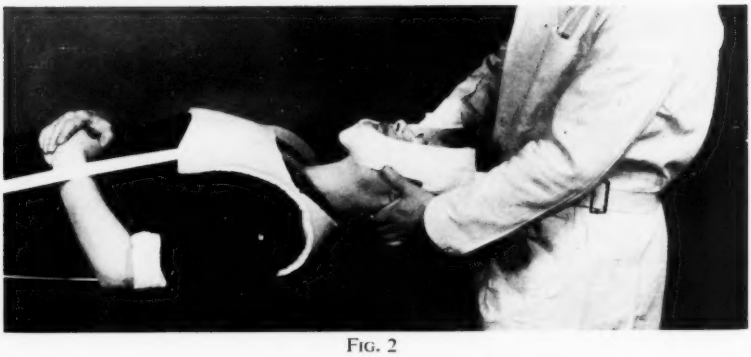


FIG. 2

of inability to maintain a pull while the cervical spine is rotated. Adequate traction is essential to the success of the manoeuvre, for without it muscle spasm cannot be overcome, and a free range of rotation is impossible. The apparatus shown (Fig. 1) enables the hands of the

manipulator to be free to control the head while traction is maintained by his body weight (Fig. 2). It has proved very useful in the treatment of acute cervical disc symptoms, which have usually resolved completely within twenty-four hours of the manipulation. Cases of a more chronic nature have not shown the same response.

The head harness and the cuirasse for the shoulders have been made from orthopaedic felt, three-eighths of an inch thick. The head portion is best constructed from two Y-shaped pieces of felt, the limbs of which are stitched together to form the chin and occipital pieces. The junction of the limbs of the Y should be strengthened with stitching. The shoulder piece is a large square of felt in which a central hole has been cut for the head to pass through. The straps, which are made of webbing, must be long enough to allow attachment to the far end of the examination couch.

I am grateful to Sister Hayer of the Royal National Orthopaedic Hospital for making up the apparatus, and to Mr R. J. Whitley of the Photographic Department of the Institute of Orthopaedics for the illustrations.

THE EFFECT OF BONE BANK PRESERVATION ON THE CALCIFYING MECHANISM*

LEROY S. LAVINE, MARTIN BURGER and ALBERT E. SOBEL, NEW YORK, U.S.A.

From the Department of Surgery, Division of Orthopaedic Surgery, State University of New York College of Medicine at New York City, and the Department of Biochemistry, Jewish Hospital of Brooklyn, New York

A fundamental orthopaedic problem to-day is the understanding of the fate of bone transplants. Since homogenous preserved bone is increasingly used, this study investigated the survival of the calcifying mechanism under storage conditions typically employed in preserving homogenous bone for orthopaedic use.

It was our hope that the method might be used to indicate the relative value of the various means of preserving bone.

The enhancement of the value of the preserved bone used in transplantation by reactivating the calcifying mechanism presented another subject of inquiry.

Calcification *in vitro* of the hypertrophic epiphysial cartilage of rachitic rat tibiae was employed in this study. This method is a useful indication of " local factors " involved in calcification.

The appearance of new calcification depends on the functioning of the complete system essential for mineralisation. This method is a valid one for the purpose of this investigation, for the histological appearance of calcification *in vitro* of the hypertrophic epiphysial cartilage resembles that obtained in calcification *in vivo*. New mineral deposits occur in the matrix and have a honeycomb-like structure. X-ray diffraction studies have shown that the new mineralisation obtained has the same lattice for calcification *in vitro* as that found for calcification *in vivo*, namely apatite (Sobel and Hanok 1952).

PROCEDURE

Young rats of an original Wistar strain were kept on the stock diet (Bills, Honeywell, Wirick and Nussmeier 1931) for three to four weeks. The animals were then placed on a rachitogenic diet that consisted of 75 per cent degerminated corn meal, 19 per cent wheat gluten, 2 per cent brewer's yeast, 3 per cent calcium carbonate and 1 per cent sodium chloride. De-ionised water was accessible to the rats at all times. After twenty-three to twenty-five days on this diet the rats were killed by chloroform asphyxiation. The proximal ends of the excised tibiae were freed from adhering soft tissue and sliced longitudinally, in a frontal plane, into sections approximately one millimetre in thickness.

The sliced sections were preserved by four methods used in storing bone for orthopaedic use. 1) The deep-freeze method (Bush 1947) was modified as follows. The tibial sections were stored at −20 degrees Centigrade for two weeks. Thereafter the sections were brought to room temperature and incubated at 37 degrees Centigrade for eighteen hours in an inorganic salt solution, hereafter called the calcifying solution. 2) The aqueous merthiolate method (Reynolds and Oliver 1949) was modified by soaking the tibial sections for two weeks, at room temperature, in a 1 : 1000 merthiolate solution. At the end of this time the sections were washed with 1 : 5000 merthiolate solution and then incubated in the calcifying solution. 3) The acetone method (Sabanas, Janes, Dahlin and Heilman 1955) consisted of soaking the tibial sections in freshly distilled acetone for two days. The supernatant was poured off and the sections were soaked again for another twelve days in freshly distilled acetone. After this interval the sections were taken from the acetone and air dried. They were then incubated in the calcifying solution. 4) In the boiling method (Lloyd-Roberts 1952) the sections were boiled for thirty minutes in distilled water. The water was poured off through a cotton gauze pledget and the sections were transferred with forceps to a small Erlenmeyer flask. The tightly stoppered flask and its contents were stored in a refrigerator at 4 degrees Centigrade.

* Reproduction in whole or in part is permitted for any purpose of the United States Government.

After two weeks the sections were brought to room temperature and boiled again for twenty minutes in distilled water. They were then removed from the water, allowed to cool to room temperature and incubated in the calcifying solution.

Calcium chloride treatment of preserved sections—Two solutions of calcium chloride were employed. One solution contained 150 m.eq./L of Ca^{++} and the other 500 m.eq./L of Ca^{++}. After the period of storage had elapsed, the sections were shaken for one hour either in the 150 m.eq./L of Ca^{++} solution or in the 500 m.eq./L of Ca^{++} solution. After this treatment the sections were rinsed with double-distilled water, blotted on a smooth filter paper, and incubated in the calcifying solution.

The stock calcium chloride solution contained 1000 m.eq./L of Ca^{++} and was specially prepared from a pure grade of calcium carbonate. The conversion of the carbonate to the chloride was accomplished by adding small portions of 6N HCl. (The concentrated HCl that was used was freshly distilled.) The calcium chloride solution thus obtained was evaporated to dryness, heated at 150 degrees Centigrade overnight in an oven, and diluted the next day with double-distilled water to produce a solution containing 1000 m.eq./L of Ca^{++}.

It is important that the presence of inhibiting ions in the calcium chloride solution be detected. This is done by shaking freshly excised rachitic tibial sections in the aforementioned calcium chloride solutions for an hour. The sections are then rinsed with distilled water and incubated in the calcifying solution. The *in vitro* calcification of the calcium chloride treated sections should show more intense mineralisation than the untreated control sections.

The calcifying solution was prepared by adding to a one-litre volumetric flask 100 millilitres of a stock basal salt solution* and 50 millilitres of a $Na_2HPO_4-NaH_2PO_4$ solution whose phosphorus concentration was 1 milligram per millilitre. The pH was lowered to 6·3 by aerating with 100 per cent CO_2. To this solution were added 5 millilitres of specially prepared calcium chloride solution (see above) whose concentration was 20 milligrams per millilitre. Double-distilled water was added to the litre mark. The pH of the final solution was adjusted to pH 7·3 by aerating with 100 per cent nitrogen. A Beckmann pH meter was used.

Calcification *in vitro*—For *in vitro* calcification each section was placed in a 50-millilitre Erlenmeyer flask filled with the calcifying solution at pH $7{\cdot}3 \pm {\cdot}05$. The flask was tightly stoppered with a paraffined cork and a rubber band that ran doubly over the cork and under the bottom of the flask. This precaution was taken to prevent any pH change. The flask and its contents were incubated at 37 degrees Centigrade for eighteen hours. After incubation the section was removed with forceps, rinsed with double-distilled water, and placed in the concavity of a glass spot plate. The section was then covered with a 3 per cent silver nitrate solution, exposed to the light from a 100 watt tungsten filament lamp for five minutes, and examined with a Leitz wide-field stereo-binocular microscope. A magnification of 32× was employed. The degree of *in vitro* calcification was assessed as described by Sobel *et al.* (1949, 1952) and as noted in the footnotes under Tables I and II.

Before any treatment a tibial section from each animal used in an experiment was placed in a glass plate concavity, covered with 3 per cent silver nitrate solution, and exposed to the tungsten filament light for five minutes. If a silver stain was observed in the epiphysial cartilage it indicated healing of rickets and the animal was discarded.

RESULTS

Table I summarises the methods of preservation and the degree of *in vitro* calcification. From these results it appears that the calcifying mechanism in the rachitic epiphysial cartilage is inactivated by the methods of preservation employed in this study.

However, when such sections were shaken in calcium chloride solutions after preservation, the results showed that Ca ions reactivated the calcifying mechanism. The best reactivation was obtained in the bones stored in the deep-freeze chest, for only 150 m.eq./L of Ca^{++} were required to produce a 1·5 (++++) *in vitro* calcification. The bones preserved in aqueous merthiolate and in acetone showed only traces of calcification when treated with 150 m.eq./L of Ca^{++}. However, after shaking in 500 m.eq./L of Ca^{++}, the calcification *in vitro* was 2·0 (++++) for the bones preserved by deep freezing, 1·5 (++++) for the bones stored in merthiolate, and 1·5 (++) for the bones stored in acetone. The boiled bones, even when shaken in 500 m.eq./L of Ca^{++}, showed practically no *in vitro* calcification. These results represent the mean readings of at least five sections.

* The stock basal salt solution contained 0·7M NaCl, 0·05M KCl and 0·22M $NaHCo_3$ per litre of solution. It was stored in a Pyrex brand bottle.

Previous studies by Sobel *et al.* (1952) and by Goldenberg and Sobel (1952) on the reversibility and the survival of the calcifying mechanism suggested that it might be possible to prevent inactivation of the calcifying mechanism during deep-freeze storage. Accordingly, fresh rachitic tibial sections were shaken for one hour in 150 m.eq./L of Ca^{++}. Excess calcium

TABLE I

CALCIFICATION *In Vitro* AFTER VARIOUS METHODS OF BONE PRESERVATION BEFORE AND AFTER TREATMENT WITH CALCIUM IONS

Method of preservation	Degree of *in vitro* calcification*		
	No treatment	Treatment with 150 m.eq./L Ca^{++}	Treatment with 500 m.eq./L Ca^{++}
Deep freezing	0(0) to trace	1·5(++++)	2·0(++++)
Aqueous merthiolate	0(0)	trace	1·5(++++)
Acetone	0(0)	trace	1·5(++)
Boiling	0(0)	0(0)	trace
Control	2·0(++++)	2·0(++++)	3·0(++++)

* The degree of calcification is indicated as follows: 0(0) no calcification; 1(+) trace; 1(++) broken thin line; 1(+++) almost complete thin line across the provisional zone; 1(++++) complete thin line across the provisional zone; 2(++++) heavy line across the provisional zone including the primary tongues of cartilage; 3(++++) heavy line across the provisional zone including the primary and secondary tongues of cartilage; 4(++++) practically complete calcification of the metaphysis.

TABLE II

INFLUENCE OF CALCIUM IONS ON METACHROMASIA OF DEEP-FROZEN RACHITIC TIBIAL SECTIONS

Toluidine blue in solution, uM/L	$CaCl_2$ in solution (m.eq./L)	Degree of metachromasia* in sections treated by:			
		Deep freezing only	$CaCl_2$ before deep freezing	$CaCl_2$ after deep freezing	Untreated controls
39	0·0	0	+	++	±
39	5·0	±	+	++	++
39	10·0	++	++±	+++	++++
39	25·0	+	++	++	++
39	50·0	±	+	++	+
39	100·0	0	0	0	±
39	200·0	0	0	0	0

*The degree of metachromasia was graded as follows: 0 = No purple (metachromatic) stain. ± = Broken thin line of metachromatic staining extending across the epiphysial hypertrophic cartilage. + = Continuous thin line of metachromatic staining extending across the epiphysial hypertrophic cartilage. ++ = Continuous line of metachromatic staining extending across the epiphysial hypertrophic cartilage and half way up. +++ = Continuous line of metachromatic staining extending across the epiphysial hypertrophic cartilage and three-quarters of the way up. ++++ = Complete metachromatic staining of the hypertrophic cartilage.

solution was removed by washing the sections with three changes of distilled water. The sections were then placed in the deep-freeze chest for two weeks. At the end of this time the sections were brought to room temperature and incubated in the calcifying solution. *In vitro* calcification readings of 1·5 (++++) were obtained, thus proving that the calcifying

mechanism had survived the deep-freeze treatment. Control sections that had not been shaken in the calcium chloride solution were inactivated. Fresh, untreated control sections gave 2 (++++) *in vitro* calcification readings.

The influence of deep-freeze preservation on metachromatic activity of the epiphysial cartilage was also investigated. The procedural details and the method of assessing the degree of metachromasia have been described by Sobel and Burger (1954). Further details on metachromasia and the role of chondroitin sulphate in the calcifying mechanism have been discussed by Sobel (1955).

Briefly the deep-freeze preserved sections showed zero metachromasia when soaked for eighteen to twenty hours in a toluidine blue 0* solution containing 2·5 milligrams of the dye per 100 millilitres of solution. Parallel sections soaked in the dye and containing, in addition, 10 m.eq./L of Ca^{++} gave a +++ stain. The presence of calcium ions was indeed required in the active calcifying molecule. Metachromasia was markedly enhanced when deep-frozen sections were shaken with calcium ions and then soaked in the dye solution. Similarly, when sections were treated first with calcium ions followed by deep-freeze storage, the metachromasia was again enhanced.

Table II portrays the results obtained, based on a calcium curve procedure previously described (Sobel and Burger 1954).

DISCUSSION

The calcifying mechanism present in the hypertrophied proliferating epiphysial cartilage is inactivated by all four methods of preservation. This inactivation is almost completely reversed in the case of frozen bone after treatment with calcium chloride. Moreover, the inactivation can be prevented by prior treatment with calcium chloride. In the case of boiled bone the inactivation apparently is not reversible and probably represents destruction of the mechanism responsible for calcification *in vitro*. The other two methods occupy intermediary positions with respect to reversibility.

The inactivation after freezing is of particular interest because this represents conditions under which many enzymes are preserved. It is likely that calcium ions were stripped off from a critical position because calcium chloride treatment restored the mechanism. One can visualise during the freezing process a change in shape as well as length of large molecules such as collagen and mucopolysaccharides such as chondroitin sulphate. The nature of a combination of these two compounds would probably undergo a change as a result. One can easily conceive that the calcifying mechanism which was postulated to be homologous to collagen chondroitin sulphate (Sobel and Burger 1954) underwent a reversible rearrangement to an inactive form.

If the mechanism of calcification in true bone is closely related to the mechanism in the pre-osseous cartilage, these findings would imply that freezing, either followed or preceded by calcium chloride treatment, may be a more desirable method of bone bank preservation than methods now used. We hope that further studies in progress will elucidate this point.

SUMMARY

1. The influence of various methods of preserving bone on the calcifying mechanism of the tibial epiphysial cartilage of rachitic rats was studied. An *in vitro* calcification technique was employed.

2. Preservation by deep freezing, aqueous merthiolate, boiling, or acetone inactivated the calcifying mechanism.

3. The inactivation was reversed with calcium ions, most readily in the deep-frozen bones, less readily in the merthiolate treated bones, still less readily in the acetone stored bones, and least in boiled bones.

* Toluidine blue 0 obtained from Hartman-Leddon Co., Philadelphia.

4. Exposure to calcium ions before preservation in the deep-freeze chest prevented inactivation.
5. The inactivation, reactivation and survival of the calcifying mechanism were confirmed by metachromasia studies.
6. The theory of the mode of action of calcium chloride on reactivation and survival of the calcifying mechanism is presented.

These studies were supported in part by a contract between the Office of Naval Research, Department of the Navy, and the Jewish Hospital of Brooklyn, NR 180 025; by funds provided under contract AF18(600)–1274 with the U.S.A.F. School of Aviation Medicine, Randolph Field, Texas; and by funds from Research Grant D.55 from the National Institute of Dental Research, National Institute of Health, Public Health Service.

REFERENCES

BILLS, C. E., HONEYWELL, E. M., WIRICK, A. M., and NUSSMEIER, M. (1931): A Critique of the Line Test for Vitamin D. Journal of Biological Chemistry, **90,** 619.

BUSH, L. F. (1947): The Use of Homogenous Bone Grafts. A Preliminary Report on the Bone Bank. Journal of Bone and Joint Surgery, **29,** 620.

GOLDENBERG, H., and SOBEL, A. E. (1952): Calcification IX. Influence of Alkaline Earths on Survival of the Calcifying Mechanism. Proceedings of the Society for Experimental Biology and Medicine, **81,** 695.

LLOYD-ROBERTS, G. C. (1952): Experiences with Boiled Cadaveric Bone. Journal of Bone and Joint Surgery, **34–B,** 428.

REYNOLDS, F., and OLIVER, D. R. (1949): Clinical Evaluation of the Merthiolate Bone Bank. Journal of Bone and Joint Surgery, **31–A,** 792.

SABANAS, A. O., JONES, J. M., DAHLIN, D. C., and HEILMAN, F. R. (1955): Comparison of Homologous Bone Grafts Preserved by Acetone and Formaldehyde and by Acetone Alone: Experimental Studies. Proceedings of the Staff Meetings of the Mayo Clinic, **30,** 432.

SOBEL, A. E. (1950): The Local Factor in Calcification. Metabolic Interrelations. Transactions of the Second Conference, p. 113. New York: Josiah Macy, Jr., Foundation.

SOBEL, A. E. (1955): Local Factors in the Mechanism of Calcification. Annals of the New York Academy of Sciences, **60,** 713.

SOBEL, A. E., NOBEL, S., and HANOK, A. (1949): The Reversible Inactivation of Calcification *in vitro*. Proceedings of the Society for Experimental Biology and Medicine, **72,** 68.

SOBEL, A. E., and HANOK, A. (1952): Calcification VII. Reversible Inactivation of Calcification *In Vitro* and Related Studies. Journal of Biological Chemistry, **197,** 669.

SOBEL, A. E., and BURGER, M. (1954): Calcification XIV. Investigation of the Role of Chondroitin Sulfate in the Calcifying Mechanism. Proceedings of the Society for Experimental Biology and Medicine, **87,** 7.

VASCULAR CHANGES AFTER INTERFERENCE WITH THE BLOOD FLOW OF THE FEMORAL HEAD OF THE RABBIT

ANDRÉ LEMOINE, PARIS, FRANCE*

Formerly Girdlestone Scholar in Orthopaedic Surgery, Nuffield Orthopaedic Centre, Oxford

Despite repeated attempts to provide experimental data in support of the ischaemic theory of osteochondritis of the upper femoral epiphysis, decisive laboratory evidence on the etiology of the condition is still not available. It is possible that the difficulty in substantiating experimentally any of the numerous theories still in vogue is due to the rarity with which osteochondritis of the femoral head seems to occur in the animals used for experimental study, or in any other animal. It is not even clear whether the changes reported by Thomasen (1939) in the shoulder of the Danish pig are comparable with those affecting the upper femoral epiphysis of young children.

Many investigators have assumed that osteochondritis of the femoral head is caused by interference with the blood flow to the secondary nucleus of ossification, and have attempted to reproduce in animals, usually the rabbit or the dog, the changes that are seen in children. Nussbaum (1923) excised the whole of the synovial membrane of the hip and divided the ligamentum teres in dogs, and found changes which he thought were like those of osteochondritis of the hip. Bentzon (1927) injected alcohol near the epiphysial arteries of the hips of rabbits and obtained in one-sixth of them changes which he likened to those of juvenile osteochondritis. Introzzi (see Leriche 1934) also injected alcohol around the femoral neck of rabbits and concluded that he had produced "coxa plana" in a number of them, but Miltner and Hu (1933) repeated in rabbits and dogs Bentzon's and Introzzi's experiments and were unable to confirm them. On the other hand, Zemansky and Lippmann (1929) divided the ligamentum teres and part of the hip capsule of young rabbits and found that flattening of the femoral head occurred afterwards. Kistler (1934, 1935, 1936) found that the femoral heads of rabbits could be altered in a way resembling human osteochondritis by several procedures; but Stewart (1933) divided the capsular attachment to the femoral neck in rabbits, Burrows (1941) and Lacroix (1942) divided the round ligament in rabbits, and Graham (1930) in goats, and all were able to produce changes similar to—but in their opinion not identical with—those of "coxa plana."

It appears from this short account of some of the experimental work on this subject that the interpretation of results varies more with the individual worker than with the methods used. It is noticeable that all these works, though describing the histological effects, are conspicuous for their uniform lack of information of the accompanying changes in vascular pattern. This consideration suggested that, with some of the more reliable methods of vascular investigation now available, it would be possible to study experimentally the changes in the vascular anatomy of the upper femoral epiphysis which follow interruption of the arterial blood flow.

MATERIAL AND METHODS

Sixty male and female rabbits of different ages, including a few adults, were used; but most were between the ages of two and seven weeks. Only the left hip was used in each animal, the right being left untouched as a control. In a few rabbits the *distal* femoral epiphysis had its blood flow interfered with as it had been noted that the main supply to this region came from a central posterior artery which could be easily divided.

* At present attached to the Department of Professor R. Merle d'Aubigné, Hôpital Cochin, Paris.

All the animals were operated upon under general anaesthesia with nembutal, ether and trilene. Weekly radiographs of both femora were obtained from just before the time the experiment began until the animal was killed, which was after a period varying from four days to four months. Under nembutal all the animals had a cannula placed in the abdominal aorta and several substances of varying molecule or particle size were perfused through the cannula before they were killed. The most useful injection mass was a warmed mixture of one part of a 1 per cent solution of Berlin Blue with two parts of fine barium suspension (Micropaque). The amount of the injection was approximately in millilitres half the weight of

FIG. 1
Antero-posterior and lateral angiographs of the femur of a normal rabbit.

the animal in hectogrammes. The method of injection was that described by Trueta, Barclay Daniel, Franklin and Prichard (1947) adapted for the visualisation of the vessels within the bone tissue (Trueta and Harrison 1953). After injection the specimens were fixed in 10 per cent formalin. Microradiographs were obtained with the technique described by Barclay (1951). Photographs of the specimens prepared by the Spalteholz method were also obtained in a number of experiments.

The normal vascular anatomy of the upper femoral epiphysis of the rabbit—Before analysing the results of this investigation it seems convenient to describe the normal vascular anatomy of the proximal femoral epiphysis of the rabbit, because some features differ from those found in man (Trueta and Harrison 1953, Trueta 1957).

As in man, the vascular pattern changes with growth and must always be studied in relation to age.

The main upper branches of the nutrient artery, both in the adult and young animal, vary in number from about three to six. The nutrient artery penetrates the femur where the epiphysis joins the shaft. On reaching the marrow cavity the nutrient artery divides into an ascending and a main descending branch (Fig. 1). The ascending branch gives origin to the large arterioles which distribute themselves throughout the whole of the upper metaphysis and anastomose with some of the vessels of the femoral head.

The terminal branches of the lateral circumflex artery—On reaching the narrow space between the lower border of the acetabulum and the upper aspect of the lesser trochanter—which is very large in the rabbit—this artery divides. The main terminal branch emerging from the anterior circumflex runs over the front of the femoral neck close to the capsular insertion and

FIG. 2

Posterior view of the hip joint of the rabbit after injection into the abdominal aorta. Note the anastomosis between the sciatic artery and the main terminal branch of the anterior circumflex artery.

ends by anastomosing with a branch of the sciatic artery (Fig. 2). During its course this vessel gives origin to a number of capsular arterioles at the upper part of the joint (Fig. 3). This arrangement is present at all ages.

Another terminal branch of the anterior circumflex artery runs at all ages under the transverse acetabular ligament and anastomoses with branches of the obturator artery, contributing to the blood flow through the round ligament.

Finally, a third terminal branch of the anterior circumflex artery extends round the inferior aspect of the femoral neck, penetrating the postero-inferior insertion of the capsule and, after running under the synovial membrane for a few millimetres, enters deep into the postero-inferior part of the femoral head (Fig. 4). In young animals the point of entrance of this vessel is at the junction of the epiphysial cartilage with the neck. This vessel, a true

FIG. 3

Antero-posterior and lateral angiographs of the proximal end of an adult normal rabbit's femur. Note the capsular vessels and the large artery in front of the joint.

FIG. 4

Angiographs of the proximal end of a normal adult rabbit's femur showing the course of the "nutrient" artery to the femoral head.

nutrient artery to the head, has no equivalent in man even if it resembles one of the metaphysial ascending arteries seen in early infancy (Trueta 1957). The variation that this artery undergoes during growth is caused by the fusion of the epiphysis; at about three months it anastomoses profusely with the vessels of the neck.

Perforating metaphysial arteries—These arteries vary in number and size but never reach the importance of those seen in children. They anastomose with the nutrient and the circumflex systems of vessels. Age does not seem to influence their development.

Vessels of the ligamentum teres—These vessels are greatly subjected to the changes of age, like the corresponding arteries in man.

In the *three-day-old* rabbit a sizeable vessel enters the head from the round ligament and anastomoses with the ascending branch of the circumflex artery which I have named the nutrient artery of the head.

FIG. 5

Antero-posterior angiograph of the proximal end of the normal femur of a seventeen-day-old rabbit. The " nutrient " artery to the head is seen; the arterioles of the ligamentum teres do not penetrate any longer towards the epiphysial ossicle.

At *nine days* the arteriole of the round ligament is still present but it is already decreasing in importance.

At *seventeen days* it has ceased to contribute to the nourishment of the secondary nucleus of ossification and when present does not penetrate the head (Fig. 5).

These observations are at variance with those of Zemansky and Lippmann (1929), who demonstrated by arterial injection that the vessels of the ligamentum teres supply a considerable part of the epiphysial nucleus of the rabbit at two weeks, a much smaller part at five weeks and fail to reach the nucleus at seven weeks. Burrows (personal communication) has observed vessels of the ligamentum teres penetrating into the nucleus in rabbits aged twenty-two to twenty-nine days.

RESULTS

The results obtained in the present investigation have been grouped according to the type of vascular interference which had been caused to the upper femoral epiphysis. In a separate short section the results obtained by causing vascular damage to the distal femoral epiphysis will be reported with the aim of comparing them with those found in the proximal epiphysis.

EXPERIMENT 1. LIGATURE OF THE LIGAMENTUM TERES (SEVEN RABBITS)

Through a postero-lateral incision the fibres of gluteus maximus were split and the tendons of the medius and minimus were divided near their insertion to the greater trochanter. The upper part of the capsule was then incised and a fine silk ligature was placed round the ligamentum teres by dislocating the hip.

Results—Five rabbits from two to three weeks old were used. One rabbit was killed on each of the tenth, twenty-first, twenty-eighth, thirty-fifth and sixty-fifth days. All of the first four

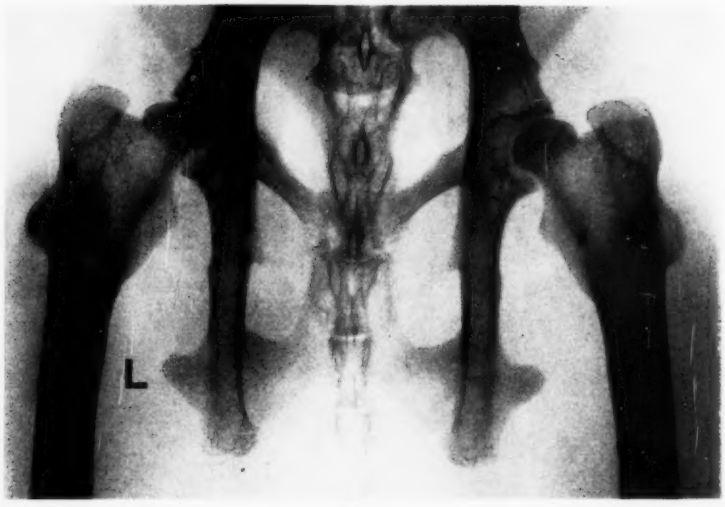


FIG. 6

Fragmentation of the left femoral head twenty-one days after the operation described under Experiment 1.

rabbits showed fragmentation of the epiphysis and flattening of the head (Fig. 6). The femoral neck appeared short and thickened (Figs. 7 and 8) and micro-angiographs showed great increase in vascularity (Fig. 9) in all but the first. In the fifth rabbit no change was seen in head or neck. (The " nutrient " vessel to the head was seen to be intact.) Two adult rabbits were killed at the fiftieth day and no change was found in the femoral head.

Comment—These results must be viewed with some caution. To ligate the round ligament a relatively large capsulotomy is necessary and a variable amount of damage to the capsular vessels is unavoidable. Moreover, to pass the needle round the ligamentum teres the femoral head must be pulled out of the acetabulum and even then the needle may cause some damage to the inner side of the capsule or to the joint cartilage. Finally, the silk is a foreign body which may cause some reaction. Further rabbits were operated on in an attempt to eliminate some of the misleading factors.

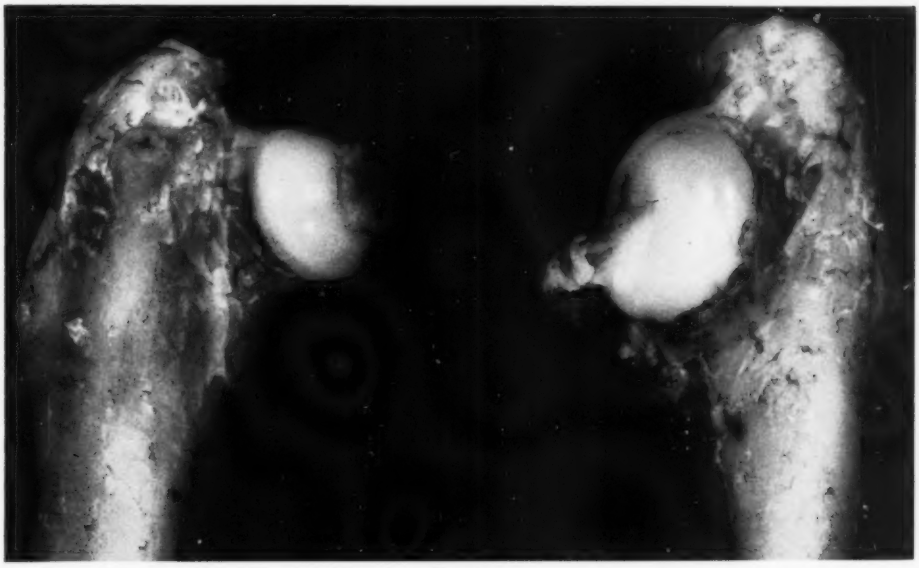


FIG. 7

Photograph of the anterior aspect of the proximal femoral end of a nineteen-day-old rabbit after the operation described under Experiment 1. The control side is shown on the left and the side operated upon on the right. Note the marked flattening of the head.

FIG. 8

Photograph of the medial aspect of the same specimen as shown in Figure 7. Note the extreme anteversion of the femoral neck on the side operated upon (*right*).

FIG. 9

Antero-posterior angiograph corresponding to the preceding specimen. Note the considerable increase in the size and number of vessels in the experimental side (*right*).

EXPERIMENT 2. DIVISION OF " NUTRIENT " VESSEL TO THE HEAD

By a postero-lateral approach to the hip, splitting the gluteus maximus and dividing the tendons of the medius and minimus and of the pyramidalis near the trochanter, the capsule was divided in its lower part and the artery divided at its entrance into the head.

Results—The sixteen young rabbits were killed between the sixth and the eighty-fifth day after operation. Every animal showed some changes detectable by radiography, histology or macroscopically, such as flattening of the femoral head and shortening of the neck, as detailed below.

Rabbit 55—Operated upon when sixteen days old. Two days later the radiograph showed some blurring of the upper femoral extremity. The animal was killed on the sixth day. The epiphysial nucleus was smaller than that of the opposite (control) side; the femoral neck was shorter than normal and in varus, and the head was flattened. Angiography showed a marked increase in vascularity of the neck and greater trochanter. There was absence of injection mass in the area of distribution of the " nutrient " artery of the head. The secondary nucleus of ossification appeared denser in the radiographs and less well vascularised than the normal, and it was injected only through a small vessel from the round ligament (Fig. 10).

Rabbit 49—Operated on when eighteen days old. The radiographs taken fifteen days later showed a slight flattening of the femoral head and osteoporosis of the upper part of the femur. Micro-angiography showed a marked hypervascularisation of the head sprouting from the vessels of the ligamentum teres and the ascending (" nutrient ") vessel (Fig. 11).

Rabbit 44—Operated on when twenty days old. Twenty-three days later the radiographs showed a flattened head, smaller than on the control side. The neck was varus. Microradiographs obtained on the same day gave clear evidence of the great hypervascularisation of the femoral head, the majority of new vessels emerging from the ascending metaphysial artery (Fig. 12). *Rabbit* 53—Operated on when nineteen days old. Thirty-three days later the radiographs showed marked osteoporosis and flattening of the femoral head with enlargement of the superior aspect. The photographs gave clear evidence of these findings (as in Figs. 6 and 7). The microradiograph showed a better arterial injection of the side operated upon, but the increase in vascularity was less marked than in the previous rabbit injected two weeks sooner after operation (Fig. 13).

FIG. 10

Angiograph taken six days after the operation described under Experiment 2, in a rabbit sixteen days old. It shows the decrease in vascularity of the secondary nucleus of ossification of the femoral head, the injection mass having reached the ossicle through the artery of the ligamentum teres, which on the control side was already undetectable.

Rabbit 59—Operated on when twenty-eight days old. Ten days later the radiograph showed porosis of the upper end of the femur, and the epiphysial ossicle was smaller than on the control side. On the seventeenth day the head appeared flattened and small in the radiograph. On the twenty-fourth day the secondary nucleus of ossification appeared fragmented and flattened and the neck was in marked varus. On the thirtieth day the head was still flattened but the structure of the epiphysial ossicle was becoming normal although the neck was still in varus. On the thirty-seventh day the head was flattened and of irregular density. The growth of the greater trochanter had been accelerated and it appeared at a higher level than that of the control side. The neck was shorter and varus (Fig. 14). On the fifty-fourth day the flattened head was tending to subluxate. On the eighty-fifth day the head remained denser than the control and subluxated. Fusion of the epiphysial cartilage, which was well advanced on the control side, was still in the early stages on the side of operation.

FIG. 11

Angiographs of a thirty-three-day-old rabbit which had the " nutrient " artery of the femoral head divided fifteen days before. The experimental side (*at right*) shows the flattening of the head and its profuse vascularity. The main source of blood is the ligamentum teres, apart from some contribution from the metaphysial vessels which cross superficially to the epiphysial cartilage.

FIG. 12

Angiographs of a forty-three-day-old rabbit, twenty-three days after the operation described in Experiment 2. The femoral head shows very considerable increase in vascularity. The control side is shown at left.

FIG. 13

Angiograph of a fifty-four-day-old rabbit operated upon when fifteen days old. The vascularity of the femoral head is less profuse than in the preceding rabbits injected and killed after shorter periods.

FIG. 14

Radiograph obtained thirty-seven days after division of the " nutrient " artery of the femoral head (*left*) in a rabbit twenty-eight days old. Note the flattening of the femoral head and the shortening and broadening of the neck.

The microradiographs at that time show that the vascularisation of the femoral head was like that of the control side but depended more on the vessels of the ligamentum teres for its blood flow than on the normal side (Fig. 15).

EXPERIMENT 3. DIVISION OF THE ANTERIOR CIRCUMFLEX ARTERY

This vessel was divided on the front of the femoral neck after the fibres of the gluteus maximus had been split and the tendon of the medius and minimus detached. This series of rabbits was grouped by age.

Results—*Eight rabbits* eighteen days old were killed from the thirty-fifth day to the hundredth day. Only a very slight tendency to flattening of the head was noted. No changes were seen in the angiographs.

FIG. 15

Angiographs of the rabbit in the preceding figure, injected eighty-five days after the operation. The vascularity of both femoral heads is very similar, but on the side of the operation (*left*) the blood supply is derived from the vessels of the round ligament and those of the metaphysis.

Six rabbits thirty-five days old were killed from the fourteenth to the ninetieth day. The femoral head appeared very slightly flattened. No change was noted in the angiographs.

Three adult rabbits were killed at the thirty-fifth, forty-second and ninetieth days. No lesion of any kind was seen.

It was thus demonstrated that the division of the circumflex artery, whatever the age of the animal, had hardly any effect upon the femoral head.

DISCUSSION

The radiographic changes appearing in the capital femoral ossicle after division of the large metaphysial branch from the anterior circumflex, which I refer to as the "nutrient" artery of the femoral head, resemble those of human juvenile osteochondritis both in their characteristics and in their evolution towards spontaneous healing, with a variable amount of permanent deformity of the head and neck of the femur.

The process by which the changes of the femoral head became established in the experimental animals was as follows. Immediately after division of the "nutrient" capital artery there was ischaemia of the ossicle, but by the eighth day revascularisation began

through the round ligament and was followed by revascularisation in the area supplied by the inferior metaphysial arteries. About the twelfth day a generalised decrease in vascularity was still detectable. Radiographically, this first anaemic stage corresponded to an increase of bone density together with a decrease in size of the secondary nucleus of ossification. After these early changes the vascularity began to increase about the fifteenth day, with the development of vessels which had already entered the head through the above mentioned routes. This vascular profusion was accompanied by radiographic signs of bone reabsorption. At this stage the experimental animals showed great restriction of muscle and joint activity from pain and muscle spasm. The bone and articular deformity, consisting of flattening of

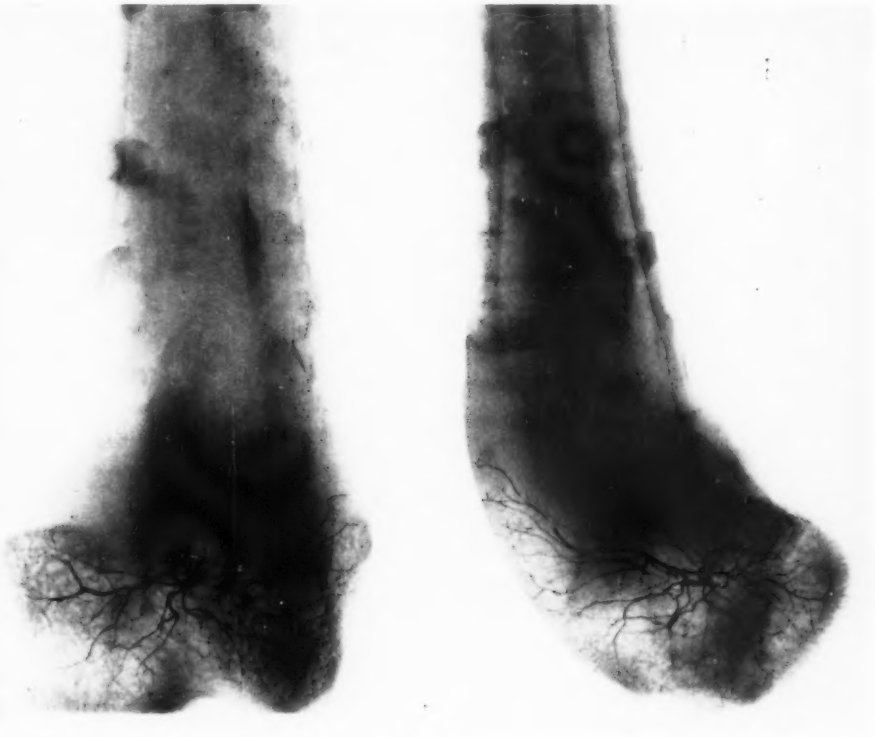


FIG. 16

Antero-posterior and lateral arteriographs of the distal femoral epiphysis of an adult rabbit showing the large and single epiphysial artery entering the bone from the back.

the femoral head and inclination of the neck in varus and anteversion, appeared during this phase of the post-ischaemic process.

About the ninetieth day after operation the hyperaemia ceased and the experimental disease may be considered to have ended but it left a permanently deformed hip joint and a prematurely fused epiphysial cartilage.

EXPERIMENTS UPON THE DISTAL FEMORAL EPIPHYSIS

In the course of studies in this laboratory on the vascular patterns of bones it has been observed that the distal femoral epiphysis of the rabbit is mainly supplied by a large branch from the popliteal artery which is situated near the centre and back of the intercondylar notch.

After passing underneath the capsule it penetrates the bone at the proximal aspect of the epiphysis, and from there is expanded in all directions without crossing the barrier of the epiphysial plate up to three months of age. It anastomoses in young rabbits with periosteal and perforating vessels which penetrate the bone at different points of the capsular insertion (Fig. 16). In adult rabbits this central epiphysial vessel anastomoses freely with the terminal branches of the nutrient artery.

Since this artery supplies the main blood volume to the distal femoral epiphysis, it was decided to investigate whether changes could be produced in the epiphysis by its division.

In seven rabbits the vessel was exposed by a medial longitudinal incision and divided.

Four adult rabbits were killed at fifteen, forty-five, sixty-five and ninety days afterwards. No change in the epiphysis was noted, and the microradiographs were normal in all cases.

Three rabbits aged fourteen, twenty-one and thirty-five days were operated upon. The first and last animals showed a very slight shortening of the femur, together with an extremely discrete hypervascularisation. The rabbit operated on at twenty-one days was killed fourteen days later and showed a posterior slipping of the distal femoral epiphysis together with some hypervascularisation.

Comment—It is of interest that, in an epiphysis like the distal femoral epiphysis where the vessel supplying it anastomoses with a number of periosteal and perforating vessels during growth, no changes of ischaemic-hyperaemic nature were produced by the interruption of this main artery. This further supports the belief that the " osteochondritic " changes occurring in the upper femoral epiphysis after division of the main artery are dependent on the peculiar local anatomical arrangement which places the responsibility for the blood supply of the growing epiphysis on one large vessel or group of vessels.

CONCLUSIONS

1. By the surgical division of the main capsular artery supplying the upper femoral epiphysis of the rabbit it is possible to cause changes which resemble those occurring in human osteochondritis.
2. The phase of anaemia (ischaemia and hypovascularisation) lasts in the rabbit less than fifteen days. The whole process lasts approximately ninety days, and only for one-sixth of this period does the femoral head suffer from a reduction in its blood supply.
3. After the fifteenth day until the end of the process the condition changes to one of hypervascularisation, which lasts six times longer than that of ischaemia or relative anaemia.
4. By the ninetieth day the whole process has lost its activity and only some permanent deformities remain. The vascular pattern is from then on the normal in the rabbit.
5. The " osteochondritic " changes cannot be elicited in the distal femoral epiphysis. The apparent reason is the presence of anastomoses between the main artery and other epiphysial vessels.
6. There seems to be reasonable experimental evidence, by implication, in favour of the vascular theory of osteochondritis of the upper femoral epiphysis in children.

I must express my gratitude to Professor J. Trueta for his constant help and encouragement throughout this work. I would like to express my thanks to Professor R. Merle d'Aubigné for his advice. I am also grateful to Mr D. W. Charles and Mr A. H. Mann for their technical contribution.

REFERENCES

BARCLAY, A. E. (1951): Micro-Arteriography. Oxford: Blackwell Scientific Publications.

BENTZON, P. G. K. (1927): Roentgenological Investigations Concerning the Arterial Supply of the Epiphyses. Acta Radiologica, **8**, 618.

BURROWS, H. J. (1941): Coxa Plana, with Special Reference to its Pathology and Kinship. British Journal of Surgery, **29**, 23.

GRAHAM, R. V. (1930): Experimental Considerations in Perthes's Disease. Medical Journal of Australia, **i**, 207.

KISTLER, G. H. (1934): Sequences of Experimental Infarction of the Femur in Rabbits. Archives of Surgery, **29,** 589.

KISTLER, G. H. (1935): Sequences of Experimental Bacterial Infarction of the Femur in Rabbits. Surgery, Gynecology and Obstetrics, **60,** 913.

KISTLER, G. H. (1936): Effects of Circulatory Disturbances on the Structure and Healing of Bone. Injuries of the Head of the Femur in Young Rabbits. Archives of Surgery, **33,** 225.

LACROIX, P. (1942): Les vaisseaux du ligament rond dans la pathogénie de la coxa plana. Revue d'Orthopédie, **28,** 30.

LERICHE, R. (1934): Recherches expérimentales sur le mécanisme de formation de l'ostéochondrite de la hanche. Lyon Chirurgical, **31,** 610.

MILTNER, L. J., and HU, C. H. (1933): Osteochondritis of the Head of the Femur. An Experimental Study. Archives of Surgery, **27,** 645.

NUSSBAUM (1923): Demonstration über die Erzeugung von Osteochondritis juvenilis auf experimentellem Wege. Zentralblatt für Chirurgie, **50,** 937.

STEWART, W. J. (1933): Aseptic Necrosis of the Head of the Femur Following Traumatic Dislocation of the Hip Joint. Journal of Bone and Joint Surgery, **15,** 413.

THOMASEN, E. (1939): Calvé-Perthes-like Changes in the Head of the Humerus in Swine. Acta Orthopaedica Scandinavica, **10,** 331.

TRUETA, J. (1957): The Normal Vascular Anatomy of the Human Femoral Head During Growth. Journal of Bone and Joint Surgery, **39–B,** 358.

TRUETA, J., BARCLAY, A. E., DANIEL, P. M., FRANKLIN, K. J., and PRICHARD, M. M. L. (1947): Studies of the Renal Circulation. Oxford: Blackwell Scientific Publications Ltd.

TRUETA, J., and HARRISON, M. H. M. (1953): The Normal Vascular Anatomy of the Femoral Head in Adult Man. Journal of Bone and Joint Surgery, **35–B,** 442.

ZEMANSKY, A. P., Jun., and LIPPMANN, R. K. (1929): The Importance of the Vessels in the Round Ligament to the Head of the Femur During the Period of Growth, and their Possible Relationship to Perthes' Disease. Surgery, Gynecology and Obstetrics, **48,** 461.

PROCEEDINGS AND REPORTS OF UNIVERSITIES COLLEGES, COUNCILS AND ASSOCIATIONS

GREAT BRITAIN

BRITISH ORTHOPAEDIC ASSOCIATION

AUTUMN MEETING 1957

The Autumn meeting of the British Orthopaedic Association was held in London on October 3–5. The president, Mr Philip Wiles, was in the chair.

At the Instructional Course on October 3 the following lectures were given: *Osteoporosis* (Mr H. Jackson Burrows, London); *Osteochondritis of the spine* (Mr R. W. Butler, Cambridge); *Dislocation and fracture-dislocation of the hip* (Mr E. A. Nicoll, Mansfield); and *The management of scoliosis* (Mr J. I. P. James, London).

On October 4 the morning meeting was devoted to short papers.

Genetics in orthopaedics—*Dr Cedric Carter* (Clinical Genetics Research Unit, Institute of Child Health, London) said that orthopaedic conditions could be divided into three groups: 1) those in which an abnormal genetic constitution, often a single gene mutation, was solely responsible; 2) those due purely to environment; and 3) those, such as congenital dislocation of the hip, in which both factors were significant. Studies of monozygous twins had proved most helpful in differentiating these groups, group (1) being always concordantly affected, group (2) no more often concordant than in dizygous pairs, and group (3) showing notably greater concordance than in dizygous pairs—for example, in congenital talipes equinovarus there was a 23 per cent concordance in monozygous twins but only 2 per cent in dizygous twins. Environmental diseases were becoming less common with improved public health, whereas largely genetic ones tended to increase in frequency not only with the increase in mutations due to radiation, but also because better medicine had led to a greater survival and therefore reproductive rate amongst those possessing such mutants. Herein lay a danger, unless counteracted by advice to such parents on the risks to their children.

Mutations might be dominant or recessive. The former produced an effect even in heterozygotes—that is, when paired with a normal gene on the other chromosome of the pair; whereas the recessive produced an effect only in homozygotes—that is, when paired with another of similar type. Family histories showed that achondroplasia and dysplasia epiphysialis multiplex were the result of dominant mutant genes, whereas Morquio's form of osteochondrodystrophy was usually dependent on a recessive mutant gene.

With dominant genes a family prognosis was straightforward; sporadic cases would be due to fresh mutations and later brothers and sisters were most unlikely to be affected. But the risk for the children of those affected, if they survived into adult life and married, would be 50 per cent (i.e., 1 in 2). Homozygotes for recessive mutations could only arise when two clinically healthy people, each of whom were heterozygous for the same mutant gene, married. There was then a 1 in 4 risk of any child being homozygous and clinically affected, a 2 in 4 risk that any child would be a carrier but clinically normal, and a 1 in 4 chance that the child would not have the recessive mutant gene at all. It followed that once an affected child had been born, the risk for later children was 1 in 4, but the normal brothers and sisters and also the affected child, if surviving, would not have affected children unless they were unlucky enough to marry a carrier. The main hope for prevention here lay in finding ways of detecting clinically normal heterozygotes, and warning them of the risks to their children if they married each other. This was now being done in Italy, for example, to reduce the frequency of the lethal blood disorder known as Cooley's anaemia.

A special class of recessive mutations was that of the X chromosomes, where heterozygous females having two X chromosomes were clinically normal, but males with the mutation on their single X chromosome were not protected by a normal gene on the Y chromosome and were affected.

Most childhood muscular dystrophies were due to sex-linked recessive mutations. This was true of all those who were severely affected and were off their feet by the age of eleven years. They were all boys and their families showed a sex-linked recessive pattern of inheritance. The milder, but otherwise similar, cases were as often boys as girls and were mostly due to an ordinary, not sex-linked, recessive mutant gene.

Dr Carter mentioned spina bifida cystica, talipes equinovarus and congenital dislocation of the hip as examples of mixed genetic and environmental origin. In congenital dislocation of the hip 6 to 7 per cent of the sisters of affected children were also affected and about the same proportion of daughters. Brothers and sons were less often affected. This might well be due to a dominant mutant gene with only one-fifth to one-tenth of the females with the gene clinically affected, and even fewer boys with the gene affected. The environmental factors concerned were not fully known. The condition was commoner after breech birth, and it had recently been shown by Record and Edwards in Birmingham that it was also commoner in first-born babies and in babies born in winter. Before we could hope to reduce the incidence of such affections much further work was required to pick out those with the genetic constitution for the disorder but clinically unaffected, and also the environmental factors that led to the clinical manifestation of the genetic constitution. *Mr G. C. Gordon* (Carlisle), discussing the mechanism of etiology in congenital malformations, said that there must be a single item of incoordination in early development in human beings during the first three months.

Diaphyso-epiphysial resection for bone tumours of the knee—*Professor Merle d'Aubigné* (Paris) described his experience with this procedure, recommending that it be considered for certain giant-cell tumours, or in suitable cases of sarcoma when amputation was refused. Acrylic prostheses to bridge the gap tended to loosen and break, and massive homogenous grafts were slow to unite and all underwent aseptic necrosis. Autogenous grafts were better, but had proved liable to fracture. He now recommended the use of a long Küntscher nail to maintain length and rigidity, with a massive autogenous graft consisting of the anterior half of the upper two-thirds of the tibia rotated through 180 degrees so that the lower end fitted into a notch cut in the remains of the femur. The posterior part of the gap and the space left in the front of the tibia were filled with grafts from the bone bank. His first nine cases had given encouraging results and he ended an admirable presentation by showing an excellent film of the operative procedure.

Delayed primary closure following sequestrectomy in chronic osteomyelitis—*Mr Arthur Bryson* (Kano, Nigeria) said that gross chronic osteomyelitis with honeycombed involucrum and massive sequestrum, familiar to us only in museum specimens, was still common in undeveloped countries. To leave the area packed open after sequestrectomy as in the Winnett-Orr method led to slow healing with excessive formation of scar tissue, thin skin cover of poor quality and considerable risk of recurrence. After sequestrectomy and full saucerisation of the involucrum he preferred to suture the skin lightly over a dry gauze pack and suitable antibiotics and to perform delayed primary suture four or six days later. He did not recommend relaxing incisions—the blood supply to the skin was too poor in these very chronic cases—but occasionally a pedicle flap was helpful. Regarding the dead space left by this method he had found muscle flaps useless for filling them. The cavity filled naturally with blood clot, which was harmless so long as it did not raise the skin flaps. Streptomycin and penicillin were injected into the cavity on alternate days for a week, the haematoma occasionally needing aspiration. Complete healing was obtained early by this method; a few wounds broke down centrally on a small scale but the small area of bone thus exposed soon healed over. *Mr H. J. Seddon* (London), expressing appreciation of this important work, mentioned that Mr Bryson's practice extended to nineteen million people and stressed the difficulties under which he laboured in Nigeria.

Ancient and modern orthopaedics in China—*Mr J. S. Horn* (Peking) gave a fascinating review. Although modern medicine was still a newcomer to China, illustrations reproduced from early Chinese works showed the similarity of the methods evolved to those only developed in the West many centuries later.

Symposium on Bone

The histological structure of bone—*Professor D. H. Collins* (Sheffield), after briefly reviewing the normal structure of bone and stressing that bone cells could not survive more than a fifth of a millimetre from a capillary, discussed the development of membrane bone. In the first stage there was proliferating mesenchymal tissue that came under the influence of ill-understood osteogenic factors; they might be the products of certain epithelial cells. Then followed the production first of argyrophil reticulin fibres and then of collagen fibres by the fibroblasts, together with a mucopolysaccharide base substance. The resultant tangle of fibres (the woven bone anlage) enmeshed cells which became osteocytes and formed a calcifiable medium in which the primitive bone islands developed. Around these islands

osteoblasts appeared, laying down lamellae of osteoid tissue with parallel-running fibres. Lamellar bone differentiated from this tissue and was eventually substituted for all the woven bone, which was removed by osteoclasts as the marrow spaces and their contained tissues developed. In mature lamellar bone the osteocytes had long processes all interconnected, and he mentioned the importance of the endosteal osteoblasts, the endosteum being a far more extensive affair than the periosteum. The exact mechanism of bone resorption by the osteoclasts was still unknown. He concluded by demonstrating the various stages of bone development that could be found in osteogenic sarcomata and stressing the living qualities, the non-static properties, and the interchangeability of all elements of bone.

Microradiography of bone—*Dr H. A. Sissons* (London) explained the technique of microradiography, which is a form of contact radiography withstanding high magnification and limited basically by the fineness of the photographic emulsion. It had many applications, the most important of which lay in the study of the radiographic changes seen in tumours and in various types of rarefaction. Two techniques were available, using either a thick slab for the study of whole trabeculae and their arrangement, or thin ground sections for studying the distribution of bone salts. It had been found that an individual osteone in bone took about six weeks to develop; mineralisation was not complete at the end of that time but continued for some months. Studies of the degree of mineralisation in the various osteones of a bone section enabled an estimate to be made not only of the age of that piece of bone tissue but also of the rate of turnover taking place therein. The latter had been found to be faster in young subjects than old.

Electron microscopy of bone—*Dr Sheila Fitton-Jackson* (London) described how this technique had opened new fields of study of the organic and mineral structure of bone, and in particular the relationship between the collagen fibres and the hydroxy-apatite crystals. Sections were made from minute fragments embedded in plastic and decalcified or trypsin-digested according to the tissue to be studied. The arrangement of the collagen fibres and their banded structure produced pictures of strange beauty. It was still uncertain just how the mineral elements of bone were arranged. Whereas the Italian school believed that the bone matrix was a web more or less homogeneously mineralised, Swedish workers thought that rod-like crystals or plates were arranged around individual collagen fibres. Illustrations were shown suggesting that the salts might be present in particulate form within the fibre itself, concentrated in bands and in cross-section lying near the periphery of the fibres.

Mechanical properties of bone—*Professor G. H. Bell* (Dundee) discussed experiments designed to measure the strength and elasticity of bone. In long bones the effects of twisting, compression and traction were difficult to measure, whereas investigations of bending stresses were relatively easy to devise and to measure experimentally. His figures showed that bone was of a strength comparable to that of cast iron, although stress-strain graphs showed a very different pattern. In rats a low calcium diet resulted in more fragile bones, but the actual breaking stress remained constant per unit of material in cross-section—that is, the quality of the material remained unaltered, as also in limbs to which the anterior nerve roots had been divided. In contrast to this in lathyrism, which was a condition of collagen poisoning, the breaking stress was reduced by 25 per cent although bone weight and ash content remained unaltered. It was not known whether this was due to alterations in the structure of the collagen or its relationship to the mineral elements, but he believed that the explanation was to be found in the cells themselves. He concluded by describing experiments designed to measure the force necessary to crush a vertebral body at various levels; even in osteoporosis a load of one-third of a ton might be necessary; it was, however, difficult to imitate the condition found *in vivo*, and results had therefore been difficult to interpret.

Radioactive isotopes and bone—*Dame Janet Vaughan* (Oxford) pointed out that radioactive elements occurring in the " fall-out " which entered the body were concentrated in the skeleton, where they were manifested by the production of anaemia, certain changes in the bones themselves, and the production of neoplasms. The vital factor was the radiation dosage; once the element was within the bone the important factors were, 1) the character and 2) the energy of the radiation, together with 3) the half-life of the element, and 4) the character of the decay products. All investigations had been complicated by the large number of variables. There was a marked difference in species resistance, and other important factors included the amount ingested, the route of ingestion, the diet at the time, the duration of ingestion, the site of deposition and the pattern of subsequent bone growth. In describing experiments with ^{90}Str in the rabbit, she showed how the age of the rabbit controlled the pattern of deposition in accordance with the site and rate of bone growth at the time; it was the local concentration of a radioactive element that was dangerous from the tumour-formation aspect. Work on these extremely complex problems was still at a very early stage, and it was rash to assume that the behaviour of one radioactive element would resemble that of any other.

The morning of October 5 was devoted to short papers.

The short leg in poliomyelitis—*Mr A. H. C. Ratliff* (Manchester) had analysed by radiographic measurement the degree of shortening of the leg after an attack of poliomyelitis confined to that limb. The greatest shortening was seen in patients infected at the age of about three years; very few patients infected after the age of eight suffered leg shortening. Only six of the 220 patients studied had no resultant shortening. In only one was the shortening more than three and a half inches. In general the more severe the paralysis the greater the degree of shortening. In 94 per cent both femur and tibia were involved, in most instances the tibia being the more severely affected. In only one patient was the femur alone shortened. The disparity started to appear without delay after the illness. Cases could be divided into three groups according to their subsequent progress: a severe group in which the disparity increased steadily to about two and a half inches during the subsequent nine years; a milder group in which deterioration was slower but still progressive; and a third group in which shortening progressed to an inch to an inch and a half in a few years, the disparity thereafter remaining constant. Reduction of discrepancy never occurred. Children infected in the 0–2 and 4–7 year age groups showed no significant differences in the subsequent degree of shortening. Prognosis was difficult; when the paralysis was confined below the knee the greatest shortening seen was one and three-quarter inches, there being no apparent difference whether one or more muscle groups were affected. When muscles were involved both above and below the knee, severe paralysis might involve shortening up to three and a half inches, mild cases up to one and a half inches. But cases of severe paralysis had been seen with only slight shortening. *Mr W. D. Coltart* (London) asked whether Mr Ratliff's figures might have led to different conclusions if the shortening had been analysed as a proportion of the height of the child. *Mr J. I. P. James* (London) stressed that radiographic measurement was essential, although clinical examination must be added to exclude such contractures as could produce foreshortening of the bones and therefore inaccuracies on the radiographs. Although he agreed that it was in general true that the worse the paralysis the greater the shortening, he had encountered one case in which a totally paralysed leg was an inch longer than its normal fellow. *Mr D. M. Brooks* (London) asked whether all Mr Ratliff's patients with only below-knee paralysis had worn supports? The answer was in the affirmative. *Mr A. H. C. Ratliff*, answering Mr Coltart, said that this method had proved too complicated; he also remarked that Green of Boston had occasionally noted lengthening rather than shortening in a paralysed limb during the first two years after the disease, but that this had always proved a temporary phase.

Restoration of elbow flexion after paralysis—*Miss Ann Segal* (Paris), introduced by Mr H. J. Seddon, had analysed the results of forty-one operations. Of these seventeen had been Clark's transplant of the lower part of pectoralis major, eight the Brooks-Seddon procedure with the upper part of pectoralis major; thirteen Steindler's operation of proximal transplantation of the common extensor and flexor origins; and three triceps transplants. Because supination was so often passively restricted in these cases before operation she had not attempted to analyse this movement in the results; she had noted however that pectoralis transplants were the least effective in restoring active supination, and that Steindler's operation did *not* produce fixed pronation. Some subsequent restriction of extension was universal; this was most marked—up to 90 degrees— in the Steindler procedure, but was not necessarily a disadvantage as the transplant was then working over a mechanically more effective arc of movement.

After Clark's operation half the patients had good or excellent results with good supination and little limitation of passive extension. The latter factor might necessitate a trick movement to initiate flexion. The operation might interfere with any remaining function in biceps. Its great disadvantage was that arthrodesis of the shoulder was frequently necessary to make it effective.

The Brooks-Seddon procedure was not so effective as Clark's operation but was useful when only the upper part of pectoralis major was functionally adequate.

The Steindler operation gave the best results; nine out of thirteen were good or excellent and there were no failures. It did not interfere with any remaining function in biceps, it effectively limited extension, and restored some active supination. It did not interfere with shoulder movements. Its disadvantage was that elbow flexion was accompanied by wrist extension and finger flexion; arthrodesis of the wrist was required in one case in which the wrist flexors were stronger than the wrist extensors.

Triceps to biceps transplantation had the great disadvantage of loss of all active extension. It might nevertheless be useful if no other activating muscle was available, or to aid a pectoralis transplant.

In assessing these results it was found that the patient was more often satisfied than the surgeon. Only two contra-indications to operation were found: 1) a completely paralysed insensitive hand when amputation through the forearm was refused; and 2) the presence preoperatively of such active flexion power of the elbow that no worthwhile increase of power could confidently be expected from a muscle transplant.

The surgical treatment of tardy ulnar neuritis—*Mr Geoffrey V. Osborne* (Liverpool) in a preliminary communication described the surgical anatomy of this condition, which might follow old fractures or osteoarthritis of the elbow, or arise beside an otherwise normal joint. He had noted that the incidence or severity of the neuritis was not necessarily proportional to the degree of joint deformity. In exploring such cases he had found in almost every case a band of fibrous tissue bridging the two heads of flexor carpi ulnaris. This band lay directly over the nerve. It had a fixed attachment to the medial epicondyle and a mobile one to the olecranon; it was slack in extension and tightened with elbow flexion, compressing the underlying nerve. He considered its effect to be similar to that of the transverse carpal ligament at the wrist on the median nerve. Division of the band displayed the flattening of the underlying nerve and its proximal enlargement. He believed that tardy ulnar neuritis was usually a compression lesion and was not due to traction or friction in the ulnar groove as had been generally accepted. In thirteen cases he had simply divided this band, with results comparable with those after anterior transposition of the nerve. *Mr A. R. Parkes* (Glasgow) asked how the hypermobile type of nerve fitted in with this pathology. *Mr A. G. Apley* (London) remarked that one difficulty in accepting the analogy between ulnar neuritis and the carpal tunnel syndrome was that pain was a prominent factor in the latter and a very minor one in the former. *Mr K. I. Nissen* (London) also criticised this analogy. At the wrist the trouble was really due to synovial hypertrophy, usually non-specific. *Mr H. J. Seddon* (London) thought that the new concept might well prove to be a significant discovery. *Mr G. V. Osborne* accepted that there were cases truly due to hypermobility of the nerve. He thought that in some the swollen nerve above the band became secondarily hypermobile.

The treatment of Perthes' disease—*Mr D. L. Evans* (Southend) and *Mr G. C. Lloyd-Roberts* (London) had compared the results of treating patients with Perthes' disease with a Snyder's sling and crutches as out-patients with those obtained by traction in bed followed by walking in a weight-relieving caliper. From the out-patient group twenty-eight boys with unilateral disease were selected; the radiographs of each were matched with those of a boy of similar age and stage treated as an in-patient. The latter were selected from an in-patient group numbering over 200, and this permitted a closely comparable case to be found in twenty-four instances. This was confirmed by assessing the epiphysial indices for the affected and opposite normal hips. The results assessed radiographically in the two groups were almost identical and showed no significant difference whether age or stage of the disease was considered. The clinical features had been shown to parallel closely those of the radiographs. In view of the obvious social and economic advantages they therefore considered that out-patient treatment was the method of choice.

During the morning session *Mr Norman Capener* (Exeter) was installed as the new president of the Association.

Internal fixation in displacement osteotomy of the upper end of the femur—*Mr E. N. Wardle* (Liverpool) recommended internal fixation to obviate the necessity for plaster spica fixation, so ill-tolerated in the elderly, after osteotomies performed for osteoarthritis, old unreduced congenital dislocations, and ununited fractures of the femoral neck. There had been no operative mortality in forty-nine patients during the last five years. Results had been satisfactory, thirty-six patients having an uneventful recovery. The complications were due to technical errors or breakdown of apparatus and had not detracted from the final result. He had used Capener nail-plates bent to the required shape, and McLaughlin's nail-plates. Although rigid fixation was essential a long plate was unnecessary and delayed recovery of knee movements. Easy alteration of angle was a great advantage. The early relief of pain might encourage the patient to move the leg too early and endanger the mechanical fixation which necessarily took the strain while the hip joint was still stiff, but a period of light traction avoided this danger: the patient had to be moved rather than permitted to move himself in bed. The femoral head must be in the fully adducted position before muscle spasm would disappear. In three cases there had been non-union of the osteotomy. He concluded by stressing that for patients up to the age of fifty-five or sixty he still preferred to fix the hip in a plaster spica. *Mr J. Rowland Hughes* (Oswestry) said that if internal fixation gave equally good results it had many advantages. He recommended the use of a spline angled outwards. *Mr A. W. Lipmann Kessel* (London) said that results might be vitiated by complete fixation and lack of later adjustability. It was essential that the upper fragment should end up in the position of full adduction. The degree of abduction at the osteotomy site should be adjusted in accordance with the degree of adduction of the hip possible under the anaesthetic. Spline fixation was excellent in operations done for osteoarthritis, but not for ununited fractures of the femoral neck.

The surgical approach to the sacro-iliac joint—*Mr G. A. Little* (Galway) showed a film demonstrating his approach to the sacro-iliac joint by splitting off the outer table of the posterior part of the ilium, the gluteal muscles being left undisturbed on its outer surface. He reported twenty-seven operations, of which twenty-one were for tuberculosis. In only one instance did the parietal cortex sequestrate, in a case of staphylococcal osteomyelitis.

A theoretical analysis of hip mechanics—*Mr R. A. Denham* (Chertsey) showed an animated cartoon to illustrate the effect on hip mechanics and the stress on the femoral head of weight reduction, preservation of the length of the femoral neck, displacement of the femoral head medially, fixed abduction and adduction deformities, and the use of a stick.

Stress fracture of the tibia in athletes—*Mr M. B. Devas* (Hastings) said that "shin soreness" in athletes was a well known condition of insidious onset occurring towards the end of a run and eventually becoming severe enough to prevent further running. Rest relieved symptoms, but these recurred as soon as the patient tried to run again. He believed the cause was a stress fracture of the tibia, difficult to diagnose because it was incomplete, involving one cortex only, and late to give radiological changes. Typical fractures diagnosed and treated early might never attain the stage of radiological confirmation which had been seen in sixteen patients. The fracture in athletes usually occurred at the junction of the middle and lowest third postero-medially, in contrast to that occurring much more commonly, and typically in recruits, which affected the uppermost third; as recorded by Burrows, stress fractures in ballet dancers affected the middle third. Local tenderness and oedema were present early, and later definite thickening of the subcutaneous surface of the tibia. There was slight subperiosteal new bone formation and later a fine fracture line running usually upwards and inwards from the postero-medial cortex. The fracture might remain invisible even three months after the onset of symptoms. Repeated bending of the tibia due to powerful calf muscles was the suggested mechanism. In treatment rest from running was essential; strapping support was helpful, and in some a few weeks in a below-knee walking plaster was necessary. Training must be restarted gradually. He concluded by reviewing and contrasting the other types of stress fracture reported in the tibia.

Election of Officers, Honorary Fellows, Emeritus Fellows, Members and Associates

At a Meeting on October 4 the following were elected:

Officers and Members of the Executive Committee:

Vice-president for 1958–59: H. Osmond-Clarke (London)

Executive Committee for 1958–59:

J. S. Ellis (Winchester)
A. M. Rennie (Aberdeen)
Robert Roaf (Oswestry)
David Trevor (London)

The following Corresponding Fellows were elected Honorary Fellows:

S. Friberg (Stockholm)
F. E. Godoy-Moreira (São Paulo)
M. Guilleminet (Lyons)
Thomas King (Melbourne)
C. Marino-Zuco (Rome)
R. Merle d'Aubigné (Paris)
O. Scaglietti (Florence)
G. Wiberg (Lund)
R. Zanoli (Bologna)

The following Fellow was elected an Emeritus Fellow: S. Alan S. Malkin (Nottingham)

Members:

J. C. Agerholm (Oxford)
O. O. Cowpe (Manchester)
J. A. Mantle (Truro)
E. L. S. Robertson (Trinidad)

Associates:

A. Benjamin (London)
P. I. Busfield (London)
R. W. L. Calderwood (Pontefract)
B. Cashman (Boreham Wood)
B. T. Crymble (Belfast)
G. Dall (Cape Town)
S.-Y. H. Fang (Hong Kong)
R. C. Farrow (London)
W. D. Graham (Ilford)
C. J. Kaplan (Durban)
M. Lunz (Johannesburg)
J. T. Marcroft (St Leonards)
J. A. Van Der Merwe (Cape Town)
T. K. Mukherjea (Worksop)
J. K. Oyston (Gateshead)
H. D. W. Powell (Manchester)
W. E. Scott (Market Harboro')
J. E. M. Smith (Stoke-on-Trent)
J. Stevens (Glasgow)
H. O. Williams (Wirral)
P. F. Williams (Melbourne)
A. L. Zaoussis (Athens)

Sir Samuel Irwin

HONOURS TO ORTHOPAEDIC SURGEONS

SIR SAMUEL IRWIN, M.Ch., F.R.C.S.

Samuel T. Irwin of Belfast was recently honoured by Her Majesty the Queen, who placed the sword on his shoulder in creating him a knight-bachelor. He is no longer just " Sam " as we have known him throughout the many years during which he has travelled long distances from Northern Ireland to wherever the British Orthopaedic Association might be meeting, attending with greater regularity than most of those living close—I doubt whether he has ever missed one—he is now Sir Samuel and we are proud of him.

Of a man who was educated in Londonderry and Belfast, who held house-surgeon appointments in London, was a Captain in the medical services of the Army in the first world war, Consulting Surgeon to the Royal Victoria Hospital, Belfast, president of the Ulster Medical Society, vice-president of the British Orthopaedic Association, Chairman of Convocation of Queen's University, Belfast, member of the Parliament of Northern Ireland where his influence in the advance of surgery and science has been felt strongly, and furthermore an Irish rugby international player in the years when I was just about born—1900 to 1903—we would expect much. Our expectation is fulfilled. With great satisfaction we congratulate him on his knighthood. EDITOR.

PROFESSOR J. TRUETA, M.D., D.Sc., F.R.C.S.

In the presence of Her Majesty's Ambassador and Lady Harrison, President Kubitschek of Brazil created Professor J. Trueta, the Nuffield Professor of Orthopaedic Surgery, University of Oxford, a Commander of the Order do Cruzeiro do Sul. Professor Trueta has been attending the daughter of the President and has delivered several lectures in Rio de Janeiro and in São Paulo.

VISIT OF AMERICAN AND CANADIAN TRAVELLING FELLOWS TO GREAT BRITAIN

The Travelling Fellows for 1957, J. William Fielding of New York, Paul H. Curtiss of Cleveland, Edward D. Henderson of Rochester, Minnesota, Robert W. Bailey of Los Angeles, and Robert N. Lofthouse of Hamilton, Ontario, crossed the Atlantic aboard the S.S. *United States*, arriving in Southampton on April 23. We were met aboard ship by Mr Philip Wiles, President of the British Orthopaedic Association, Mr J. I. P. James, Honorary Secretary, and Mr J. S. Ellis, who greeted us and whisked us off to London by train.

The following evening a dinner of welcome was given at the Royal College of Surgeons in London. It was a wonderful welcome, the first of many warm and friendly receptions that were to be given everywhere we went in Britain.

During our week in London we visited the Middlesex Hospital, King's College Hospital, the Royal National Orthopaedic Hospital in London and at Stanmore, St Mary's Hospital and the London Hospital. The programmes were varied, interesting and very instructive.

We next travelled to Winchester and Alton, then on to Cardiff, and after a very pleasant visit drove to Stratford, with a brief stop at Chepstow. After a rest and a little culture at Stratford we continued on to Birmingham where the staff of the Royal Infirmary and the Accident Hospital entertained us and demonstrated their work.

We were honoured to be the guests of the British Orthopaedic Association at the Robert Jones Centenary meeting held at Shrewsbury and Oswestry. We were then driven through lovely North Wales and on to Manchester. There we enjoyed two stimulating days before travelling by car through the beautiful Lake District to Glasgow. While in Glasgow we had two good clinical days, then motored to Aberdeen through a very scenic route.

In Aberdeen the traditionally fine hospitality was brightened by famous local products: fish, flesh and fluid. Edinburgh, our next stop, was highlighted by a dinner at the Royal College, after a fine day at the Royal Infirmary and the Princess Margaret Rose Hospital.

Our visits to Newcastle, Leeds, Sheffield, Derby, Cambridge and Luton followed the same high calibre previously established and were all enjoyed and valued.

We were repeatedly impressed by the meticulous planning that had gone into our itinerary and programme. A careful compounding of scientific, clinical and cultural subjects, together with a varied social programme, prevented us from becoming bored or developing "indigestion." There was an almost unbelievable lack of repetition of subject matter, which well illustrates the tremendous field covered by modern orthopaedic surgery.

The small intimate groups promoted a lively and free discussion that was so beneficial. It was a privilege to meet men whose names are famous and to discuss with them, at first hand, topics on which they are known to be authorities; and also to hear presentations, invariably well delivered, on new work by young men who will be the future leaders of British and world orthopaedics.

British hospitals, which in many cases differ from the more modern buildings of which we are somewhat proud in the United States and Canada, have instead a proud heritage that obviously inspires many of the staff. The calibre of work was high from the nursing and technical level, right up to the surgery, which in many instances was performed with amazing speed and dexterity.

The 1957 Travelling Fellows photographed during a day of relaxation in the country. *Left to right:* J. William Fielding, Robert W. Bailey, Paul H. Curtiss, Robert N. Lofthouse, Edward D. Henderson.

We all learned new things and new approaches to old problems. It was beneficial to discuss with British surgeons the many vexing problems in orthopaedics that are so often seen, yet are so difficult to manage. We particularly enjoyed the personal hospitality shown to us in many centres and all hope that some day we may be able to return some measure of the kindness to us. Our final send-off banquet, the A.B.C. Club dinner at the Royal Air Force Club in London was a memorable occasion. It gave us an opportunity to meet again many of the men who have been Travelling Fellows to our side of the Atlantic, and who in many instances were so friendly and helpful during our visits to their cities.

This was a most valuable experience and we sincerely hope that the exchange fellowship programme may be continued in the years to come, so that many more surgeons on either side of the Atlantic and throughout the Commonwealth may be able to share in it. To the British Orthopaedic Association we extend our sincere thanks for a superlative experience, invaluable learning, outstanding hospitality and, perhaps most important of all, the acquisition of new friends. R. N. LOFTHOUSE.

SCIENTIFIC SOCIETIES AND REGIONAL ORTHOPAEDIC CLUBS

THE BONE AND TOOTH SOCIETY

The Bone and Tooth Society held a Symposium on " Osteogenesis imperfecta and dentinogenesis imperfecta " at the Institute of Orthopaedics, London, on April 2, 1957, with Dr H. A. Sissons in the chair.

Radiological aspects of osteogenesis imperfecta—*Dr R. O. Murray* (London) said that osteogenesis imperfecta, a congenital and sometimes hereditary disorder, showed failure of osteoblastic function leading to inadequate formation of subperiosteal and endosteal bone so that the long bones were thin and brittle. Because endochondral ossification was not significantly affected the bones were potentially of normal length. Multiple fractures occurred, uniting readily, but sometimes leading to shortening and deformity. The earlier fractures occurred, the worse was the prognosis. Deficiencies in other systems occurred: for instance lax ligaments (inadequate connective tissue formation), blue sclerae (either inadequate formation or abnormal translucency allowing the choroid to show through) and sometimes dental deficiencies and otosclerosis. In radiographs the long bones presented thin cortices and poor medullary trabeculation, with fractures often accompanied by exuberant callus. In antenatal cases, however, the bones tended to be short and wide. The skull showed the mosaic pattern caused by wormian bones (sometimes an early diagnostic clue). The pulp spaces and root canals of the teeth were poorly formed. In long-standing cases moulding of the inadequately calcified bones could cause basilar invagination of the skull, biconcave vertebral collapse, marked pelvic deformity and bowing of the long bones of the legs.

Dentinogenesis imperfecta—*Professor M. A. Rushton* (London) described a characteristic dysplasia of the teeth occurring in some cases of osteogenesis imperfecta; an indistinguishable tooth condition was not uncommon in families in which bone fragility, blue sclerae and otosclerosis were unknown. It was inherited as a dominant. On eruption the teeth of each dentition were translucent, gradually becoming pinkish or greyish. Finally the dentine was brown, while the enamel gave blue reflections (opalescent dentine). The teeth wore quickly and were brittle. The chief abnormality concerned the dental papilla, causing: 1) diminished proliferation of pulp cells leading to small teeth; this effect was progressive, so that roots were likely to be proportionately smaller than crowns; 2) very short life of all odontoblasts, causing disorganisation of the canalicular system of the dentine; 3) diminished ability of pulp cells to produce the normal organic matrix of dentine, and diminished mineralisation of dentine, which might be consequential; 4) a defect in the enamel which permitted it to split at a layer near its junction with the dentine (possibly related to (2)). Normal and abnormal dentine could form synchronously; so the abnormality probably resided in defective pulp cells rather than in any sort of nutritional privation of the tooth as a whole. Quite good dentine was usually formed for a period after first differentiation of the formative cells; so the periphery of the dentine was most likely to be normal.

A histological and microradiographic study of osteogenesis imperfecta—*Dr P. C. Meyer* (London) presented a case of the infantile form of osteogenesis imperfecta, with histology of decalcified bone and microradiography of thin, undecalcified, ground sections of bone. For microradiography bone samples were embedded in Perspex (polymethylmethacrylate) and ground to a thickness of 50 microns, and the sections were exposed to a source of soft x-rays for about twenty minutes. Histological study confirmed as the immediate cause of the fractures the total absence of any cortex in the long bones, because of a complete failure to form lamellar bone and the substitution of a very immature form of coarse-fibred woven bone. The small size of these bone trabeculae with their large and closely packed osteoblasts indicated a rapid rate of formation. The bone matrix was found to give a strongly positive periodic acid-Schiff reaction, much greater than that of normal cartilage matrix, osteoid or bone, and equal to that of so-called " cement lines." Examination of undecalcified bone confirmed the complete normality of the resting, proliferating and hypertrophic layers of cartilage in the epiphyses, contrasting with the complete disorganisation of bone growth in the metaphyses.

NORTH-WEST METROPOLITAN ORTHOPAEDIC CLUB

A meeting of the North-West Metropolitan Orthopaedic Club was held at Ashford Hospital (Middlesex) on May 18, 1957, by invitation of Mr F. G. Ward and Mr Dennis Walker. Fourteen members were present, and the guest speaker was Sir Harry Platt.

Clinical cases—The following cases were shown by *Mr F. G. Ward* and *Mr Dennis Walker*. 1) Three cases of arthrodesis (by the Gallie or Charnley methods) for severe Pott's fractures. 2) Two cases of valgus feet treated by Grice's operation. 3) Aneurysm of peroneal artery after a fracture of the tibia and fibula; treatment was by excision of the aneurysm. 4) Fatigue fracture of the neck of the femur treated by osteotomy and nail-plate. 5) Cyst near the acetabulum treated by curettage, with relief of pain. 6) Successful Syme's amputation for an old gunshot wound of the foot with gangrene, in a patient aged sixty-six years. 7) Tuberculous arthritis of the knee in an old man with some return of movement after patellectomy and synovectomy. The patient also had a tuberculous focus in the sternum. 8) Tuberculous arthritis of the sacro-iliac joint in a child aged two, treated by curettage. 9) A patient of seventy-two with non-union of the neck of the femur treated by insertion of a Thompson prosthesis one year ago; good result in function and no pain.

Hallux valgus—*Sir Harry Platt* said that the numerous etiological factors in hallux valgus had not been satisfactorily proved, though undoubtedly some cases were due to genetic and morphological factors and anomalies of the first metatarsal. The problem of ill-fitting shoes was now diminishing, particularly because of the educational help given by chiropodists.

Prophylactic measures in the form of interdigital toe-posts were of doubtful value. Palliative operations in the young adult (twenty to forty years) had led to further measures. Of radical operations, Keller's arthroplasty was the method of choice.

Appearance was less important to the middle-aged patient, but the mechanical result was more important. Degenerative changes were often present, and thin skin presented a problem in healing.

Although Keller's operation was generally the method of choice Sir Harry preferred excision of the metatarsal head in some cases. He agreed with filing the head, excising the bacon-like skin on the bunion and dividing the tight lateral capsule. He advised tenotomy of the extensor hallucis longus and afterwards applied a plastic toe-cap in flexion for two weeks.

SOUTH-EAST METROPOLITAN REGIONAL ORTHOPAEDIC CLUB

A meeting of the Club was held at the Royal East Sussex Hospital, Hastings, on May 25, 1957. Among the large variety of cases demonstrated were the following.

Stress fractures—*Mr M. B. Devas* showed three patients with stress fractures and described some of the interesting features of this condition, including the difficulties of differential diagnosis. One of his patients, a woman of fifty-four, had complained of a red tender swelling over the lower end of the right tibia of six weeks' duration, and radiographs showed a fairly extensive periosteal reaction with a cystic area in the bone substance which led to a provisional diagnosis of osteomyelitis. Rest in bed resulted in rapid improvement, and later radiographs proved conclusively that the lesion was a stress fracture.

A girl of twelve had soreness of the left shin for six months. She was a keen athlete and her pain was increased by exercise. Radiographs showed a periosteal reaction, and biopsy was reported to show periostitis but the condition settled with rest and later radiographs showed a return to normal.

A patient of forty had felt a sudden pain in the chest when coughing without particular violence towards the end of a normal pregnancy. Several months later a radiograph revealed a fracture of the ninth left rib and this remained painful despite the lapse of a further year. Hydrocortisone injected locally had failed to relieve the pain, but no satisfactory explanation was offered by the meeting. Local anaesthetic injections were suggested as the next line of treatment.

Tetanus—*Dr S. Burns* described a patient of sixty-five who developed tetanus within a few days of a McMurray osteotomy for osteoarthritis of the hip. The condition remained localised to the thigh but he became gravely ill. He was given anti-tetanic serum and penicillin, with Myanesin 20–30 grammes per day given through a continuous intravenous drip, and pethedine, Largactil and Phenergan four-hourly. These measures led to a gradual improvement and the condition cleared up after three weeks.

Juvenile hallux valgus—*Mr E. W. Bintcliffe* and *Mr J. T. Marcroft* showed two patients with juvenile hallux valgus treated by Stamm's operation, which gave excellent early results. Sloughing had, however, occurred in the wound area in one case, possibly because of the use of a curved incision. *Mr T. T. Stamm* pointed out that the operation could be performed simply through a straight dorsi-medial incision.

Osteoid osteoma of the tibia—This patient was shown by *Mr Marcroft* before the diagnosis had been established. He was a boy of eight with a history of pain in the lower leg for several weeks. There

was a doubtful history of injury before the onset of pain. When first examined in January 1957 h presented a marked fusiform thickening of the tibial shaft. Radiographs showed gross cortica thickening of the whole circumference of the bone, and other investigations all proved negative A biopsy failed to reveal the true nature of the lesion and it was thought he might have chroni osteomyelitis. Immobilisation gave no relief and the tibial thickening gradually increased. At th time of the meeting the case was presented as one of cortical hyperostosis, and chronic infection wa accepted as the most likely cause. Subsequently a further extensive exploration of the bone revealed a small but typical osteoid osteoma in the centre of the tibial shaft which was removed by operatio with relief of symptoms.

Traumatic arterial spasm—*Mr Bintcliffe* and *Mr Marcroft* each showed a child who had suffered fron ischaemia of the forearm and hand after manipulative reduction of a supracondylar fracture o the humerus. In both cases the antecubital fossa was explored promptly and the brachial artery wa found to be tightly constricted by spasm. Injection of local anaesthetic followed by papaverine le to the gradual return of blood through the affected part of the artery and recovery in each case becam complete.

Comminuted fracture of scaphoid bone—*Mr Marcroft* showed a man aged forty-seven with a severel comminuted fracture of the scaphoid bone. The prognosis was thought to be so poor that the proxima row of the carpus was excised within a few days of injury. The patient was able to return to heav work nine weeks after the injury, though with some weakness of his hand at that time. A year afte the injury he had slight limitation of wrist movements but a strong hand, and had been working fo several months as a railway track layer without discomfort.

Bilateral congenital deformities of hand and forearm—*Mr Bintcliffe* showed a boy now aged twelv whom he had treated between the ages of seven and nine for congenital absence of both radii and both thumbs. Treatment on each side consisted of: 1) skeletal traction by Kirschner wires through th olecranon and metacarpal necks to lengthen the soft tissues on the radial side of the forearm. This was maintained for a month. 2) Osteotomy of the ulna and transplantation of the head and upper shaft of the fibula into the lower forearm, fixed to the ulnar shaft and articulating at its lower end with the carpal bones on the radial side of the wrist. 3) Excision of the lower end of the ulna. Very considerable correction of the deformity was obtained on both sides and had been maintained since the operations of 1952 and 1953. The fibular epiphyses appeared to have continued to grow, but there was some doubt if they were closing in the latest radiographs. Function of the hands was remarkably good considering the absence of thumbs.

Creeping keloid—*Mr Devas* showed a woman of fifty-four with two keloid scars in the mid-line of the upper chest caused by burns thirty-five years ago. These scars had crept gradually across her chest over the years and continue to do so. Hydrocortisone injected locally had had no effect. The members present agreed that excision was not indicated. Radiotherapy was suggested as the best measure.

SOUTH-WEST ORTHOPAEDIC CLUB

The South-West Orthopaedic Club met at the Bath and Wessex Orthopaedic Hospital, Bath, on May 25, 1957.

Intramedullary nailing—*Mr Hugh Davies* reviewed thirty cases of intramedullary nailing of fractures of the shaft of the femur. The advantages of the method were that good position was achieved and early movement and walking were permitted. The patient was more comfortable than with other methods of treatment. Pathological fractures could be satisfactorily treated with the intramedullary nail. He had used the intramedullary nail on both sides in bilateral fractures of the shaft of the femur and he had also used it for comminuted fractures. Complications included: 1) a bursa in the buttock over the top of the nail, if it had not been pushed down to the level of the greater trochanter; 2) bending of the nail (no case of fracture of the nail had been encountered); 3) migration of the nail upwards. The nail had never migrated downwards.

Traumatic osteoma of the femur—*Mr Davies* showed a youth of eighteen with a large traumatic osteoma in the right thigh limiting knee flexion, and with cross-union of a fracture of the radius and ulna of the right forearm. The injuries had been received in a motor-cycle accident. *Mr H. J. Richards* believed that the late excision of such an osteoma might give a good result. He had experience of four cases in which osteomata had occurred in the region of the hip as a result of frame fixation. Removal of the osteomata after two years had been successful in restoring movement in three cases, but in one case in which the bone had been removed early a bony mass re-formed.

He felt that the osteoma should be left undisturbed for at least three years until it was avascular before it was excised. *Mr A. L. Eyre-Brook* believed in a conservative approach to this problem. He felt that the removal of the bony mass in this particular case would not necessarily do good or restore movement.

Traumatic removal of the major part of the medial condyle of the femur and tibia—*Mr Davies* showed a boy of fourteen in whom this had occurred as a result of a road accident. Primary closure of the wound had been effected with a split-skin graft, and movement had been encouraged when the graft had taken. The knee was now stable and flexion was possible from 180–90 degrees.

Management of fractures into the knee joint—*Mr G. S. Tupman* reviewed the literature. He favoured the treatment introduced by Perkins of traction and early mobilisation, but felt that traction with skin extension should be preferred to skeletal traction. Splintage was necessary to prevent increasing valgus deformity. The method was particularly useful in the old and obese patient. The routine treatment adopted had been: 1) aspiration of the haemarthrosis; 2) splintage, with skin extensions on a hinged Thomas's splint which was adjustable and which had been modified from the Fisk splint. Six to eight pounds' traction was applied. No movement was allowed for the first two weeks. Full extension was maintained and the quadriceps muscle was built up. After this time flexion exercises were allowed. The patient remained in bed for eight weeks, and then was allowed up, with full weight bearing at the end of twelve weeks. Four patients who had been successfully treated were demonstrated. *Mr K. Pridie* advocated operative elevation of the depressed tibial condyle in the young patient. *Mr Dillwyn Evans* said there were two types of fractures into the knee joint: 1) the hatchet type, in which a large fragment was forced outwards which could easily be replaced by operation and held with wire; and 2) the crush injury, in which the condyle was badly depressed. The semilunar cartilage obstructed reduction and he did not consider an operation was necessary or helpful in such a case. Treatment in the manner described by Mr Tupman was most successful.

Conservative treatment of slipped epiphysis—*Mr T. Price* demonstrated three patients with early slipped femoral epiphysis treated by plaster fixation only for six months. Good function had been obtained although the patients suffered loss of medial rotation of the hip, and radiographs showed the development of a " spike " in the neck. *Mr Eyre-Brook* considered that pinning *in situ* was the treatment of choice if the displacement was not marked. *Mr G. Blundell Jones* said that a Smith-Petersen nail should be inserted with care in such cases as it was possible to displace the epiphysis further during the insertion. *Mr F. C. Durbin* believed that pinning *in situ* with three or four small pins gave satisfactory fixation without causing further displacement of the epiphysis or precipitating avascular necrosis.

Calcaneo-cavus deformity of the foot treated by two-stage procedure—*Mr T. Price* described the treatment of calcaneo-cavus deformity by a modification of Elmslie's operation which had been devised by Miss Forrester-Brown, the difference being that the part of the calcaneal tendon used for the tenodesis was passed through an aperture in the interosseous membrane and around the fibula and sutured to itself. It was a two-stage procedure. First the cavus deformity was corrected by a mid-tarsal bone wedge, and then three weeks later the calcaneus deformity was corrected by removal of a subtalar wedge with transplantation of the tibialis posterior and the peroneal muscles to the part of the calcaneal tendon not used for the tenodesis. Mr Price emphasised that the operation was valuable because it could be performed at an earlier age than a stabilisation and it converted an intractable crippling deformity into a functioning foot and so promoted growth.

Treatment of cavo-varus foot and club-foot—*Mr Dillwyn Evans* described with slides his procedure for correcting a relapsing club-foot deformity of the cavo-varus type. The operation had been carried out in children between the ages of five and twelve years. He emphasised that it was important to obtain the greatest amount of correction by Kite's wedged plasters first. The equinus deformity must be overcome. The principle of the operation was to release all tight structures on the medial side of the foot and to divide the capsule of the ankle and talo-calcaneal joints and elongate the tendo calcaneus. This was important because it fixed the shape of the foot and allowed correction of the convexity of the lateral border, correction of supination of the forefoot and restoration of the lateral longitudinal arch. The bones were fixed with two staples. The tendon of the tibialis anterior muscle was usually transplanted to the outer side of the foot. Plaster immobilisation was maintained for four or six months. The operation encouraged normal growth; though it restricted side-to-side movement it avoided the rigidity of the triple arthrodesis. Failure arose mainly from inadequate preliminary correction. Insufficient care in securing a good arthrodesis of a calcaneo-cuboid joint also led to a poor result. It was easy to over-correct the foot and produce a fixed valgus deformity. *Mr K. Pridie* pointed out that the operation was a further stage in the operation of open correction

advocated by Brockman and by Perkins. *Mr Eyre-Brook* emphasised that the equinus deformit was sometimes difficult to correct in consequence of deformity of the body of the talus, and tenotomy might not help. It was important to correct it, otherwise the foot was unstable. *Mr L Henry* said that to correct equinus deformity in two cases he had split the interosseous ligamen between the tibia and fibula, which allowed the deformed body of the talus to accommodat itself in the mortise of the ankle joint.

Sclerosing osteomyelitis—*Mr A. E. Burton* reported two cases of proven sclerosing osteomyelitis, on with sarcomatous change superimposed on the initial condition and the other with uneventfu progression. 1) A man of twenty-eight attended with severe pain in his left thigh. A diagnosis o sclerosing osteomyelitis was made after radiographic examination and a biopsy. This was confirme by the Bristol bone tumour registry. His symptoms subsided and he had no further trouble for tw years, during which he was followed up at regular intervals radiographically. After two years the pai recurred and a further biopsy was performed. This showed a pre-existing bone infection wit infiltration of the whole of the cellular tissue with reticulosarcoma. A disarticulation throug the hip joint was performed. The patient was alive and well. 2) A man of nineteen complaine of severe pain in the left thigh for several weeks. A tomograph showed sclerosing osteomyelit which was confirmed by a biopsy. The symptoms were relieved by the decompression. All bloo investigations were negative. *Mr Pridie* wondered if the use of x-rays for tomographs and for observin the progress of the condition over a period of three years might have produced the malignant chang in the first case. In view of recent evidence that radiation might produce leukaemia he felt tha orthopaedic surgeons should be sparing in their requests for serial radiographs.

Perthes' disease of the hip—*Mr J. D. Kendall* reviewed 162 cases of Perthes' disease studied clinicall and radiologically. The influence of certain factors on the final state of the hip was studied. His conclusions were that weight bearing should be avoided until regeneration of the femoral epiphysis was complete radiologically. The use of a caliper did not give such satisfactory results as immobilisation on a frame. When treatment began after the age of six the result did not appear to be so satisfactory as it was between the ages of four and six, and the longer the time interval between the appearance of symptoms and the institution of treatment the worse the result appeared to be.

Remodelling of the lower radial epiphysis after fracture-separation—*Mr W. Recht* showed slides demonstrating that accurate reduction of fracture-separation of the lower radial epiphysis was unnecessary in children under the age of twelve because the remodelling process always corrected the deformity and a perfect functional result ensued.

Muscle power and development—*Mr W. Hedley Hall* introduced a demonstration by the Bath Weight-lifters' Association showing the methods used to increase the bulk and power of muscles. Weight lifting was a cult requiring a rigid discipline for its successful application. Weight lifters could not train more than three days a week because a day of relaxation was required after a day of strenuous exercise. It was possible to increase muscle power without increasing muscle bulk. It was also possible sometimes to produce atrophy of the muscles. It was interesting to note that the leader had a vertical scar in the lumbo-sacral region and confessed to having had an operation for the successful removal of a prolapsed intervertebral disc.

Surgery of the nail—*Mr A. W. Fowler* described an operation for embedded nail and onychogryposis, which had been devised by Quenu in 1887 and advocated by Zadik in 1950. Growth of the nail only took place from the germinal matrix, which was confined to the lunular area of the nail bed. The nail fold and the nail walls were reflected and the germinal matrix was excised by sharp dissection. The nail fold and nail walls covered the raw area. It was emphasised that the operation must be an exact dissection of a well defined anatomical structure. In this way recurrence would be avoided with certainty. Terminal amputation was unnecessary except when there were additional reasons for shortening the toe such as arthritis or deformity.

Some aspects of referred pain—*Mr J. Bourdillon* described a number of cases of persistent pain mostly occurring at the site of some previous injury but in which the pain appeared to be produced by a "spinal joint upset." He said that the pain was relieved by treating the latter condition by manipulation and concluded that the persistence of the pain in these patients had been due to a displacement in a spinal joint. He also extended his conclusions to referred pain as a whole. *Mr Norman Capener* found it difficult to accept that a manipulation of a spinal joint had effected a cure in some of the cases, and felt that the ordinary manipulation of the joints of the limbs during the course of the physical examination could have been responsible for the successful relief of pain.

THE FIRST OPERATION FOR TORN CARTILAGE OF THE KNEE JOINT

Mr B. H. Burns, orthopaedic surgeon at St George's Hospital, London, writes in comment on the article published by G. Murdoch in the last issue of this Journal (volume **39–B,** August 1957, page 502) that although credit for the first operation on the semilunar cartilage to relieve internal derangement of the knee has often been given to Thomas Annandale of Edinburgh, whose operations in 1883 were described in *Menders of the Maimed* (1917), the fact is that many years before that Bernard Brodhurst, orthopaedic surgeon to St George's Hospital, had operated upon torn and displaced semilunar cartilages, usually with a tenotome under local anaesthesia. Reports were published in the St George's Hospital Reports of 1867 (*St George's Hospital Gazette*, volume **42,** 1956) and referred to later by Herbert Allingham, who in 1889 wrote his book *The Treatment of Internal Derangements of the Knee Joint by Operation*, and again by Sir William Bennett, who in 1900 published an account of 253 cases with operative treatment in fifty-three. EDITOR.

CANADA

CANADIAN ORTHOPAEDIC ASSOCIATION

The twelfth annual meeting of the Canadian Orthopaedic Association was held in Edmonton, Alberta, and at Jasper Park Lodge, Jasper, Alberta, from June 16–20, 1956, under the presidency of Dr H. H. Boucher.

A Clinical Day was held at the University Hospital, Edmonton, on June 16, clinical cases being presented by members and guests from Edmonton and Calgary.

The meeting then journeyed by special train to Jasper, and, after a day of recreation on June 17, the scientific meeting reopened on June 18.

Bone cysts—*Dr Fred Preston* (Vancouver) (by invitation) considered that the term " bone cyst " should be confined to a cavity containing fluid, gas, or both, so that only two could be recognised, the unicameral cyst of childhood and the degenerative cyst of the adult. The weight of the evidence was thought to be that cysts were caused by local disturbance of bone growth and development. Perhaps injury might cause interosseous haemorrhage with encapsulation; in the incapsulated area pressure might develop, as in a subdural hydroma, causing stagnation in the blood and lymph channels about the area, and pressure erosion of the overlying bone with expansion of the overlying cortex. In an acute fracture this could not be brought about, because tearing of the periosteum would prevent the building up of pressure. The cysts of degenerative arthritis were ascribed to infractions of the articular cartilage, with which synovial fluid was forced under pressure during movement, with consequent erosion of trabeculae and expansion of the cyst until successfully resisted by the formation of a thick wall. *Dr T. A. Richardson* (Calgary) agreed that many of the conditions reported in radiographs as cystic were not in fact true cysts. *Dr H. E. Crowe* (Los Angeles) emphasised the importance of delaying operation on unicameral cysts until the cyst had left the epiphysial growth plate. Operation in the active stage incited recurrence. *Dr J. A. Freiberg* (Cincinnati) emphasised discrimination between the foreign body giant cells seen in the wall of the cyst and the tumour giant cells, which have many more nuclei. Dr Freiberg preferred to cauterise the wall of the cyst with phenol and neutralise with alcohol before introducing bone.

Improvement of hand function in tetraplegics—*Dr F. P. Dewar* (Toronto) said that during the past five years, in conjunction with the Canadian Paraplegic Association, efforts had been made to improve the function of the hand in tetraplegics by means of tendon transfer and tenodesis. Some twenty patients had undergone operation—on one hand only in each instance—and the results were illustrated by means of a coloured motion picture. Wrist arthrodesis was inadvisable because the palm was used to push wheel chairs and to move heavier objects. Tendon transfer and tenodesis were preferred to the use of gadgets because the patients had difficulty in applying these and keeping them in a useful position. Improvement by operation might enable the patient to learn to change his own catheter. *Dr W. J. Thompson* (Vancouver) emphasised that the extensors and adductors of the wrist were often available for function in tetraplegics. He had been chiefly concerned with the development of appliances to assist in essential functions, such as feeding, shaving and brushing the hair.

Adamantinoma—*Dr G. B. Elliott* (Calgary) (by invitation) and *Dr R. G. Townsend* (Calgary) gave a clinical and pathological review of adamantinoma and a report of three examples in the tibia. The first patient encountered was treated by curettage and packing with bone chips. The other two were subjected to wide resection and massive bone grafting, which was preferred because of the high incidence of recurrence. Amputation was considered not usually necessary.

Acrocephalosyndactylism—*Dr H. M. Coleman* (Toronto) and *Dr J. F. Murray* (Toronto) (by invitation) reviewed the literature of this rare congenital abnormality first described by Apert in 1908. Two cases were described and illustrated by coloured moving pictures. Exophthalmos with hypertelorism was the most striking feature—the skull was high, short and broad, and the occiput almost flat. The maxilla was hypoplastic and recessed with relative prognathism of the mandible, the nose huge and thick. The deformities of the hands were bilateral and symmetrical; usually the thumb was free and the other fingers syndactylous, or the little finger might be completely free with the rest of the fingers syndactylous. There might be restricted movements in the elbow and shoulders, sometimes with synostosis or deformity. Associated abnormalities of the hips and knees had also been described. Nails of the hands and feet might be fused together so as to present a hoof-like appearance. The feet might present complete syndactylism or the great toe alone might be free; hallux varus was invariably present. There might be associated congenital abnormalities of the heart and stenosis of the biliary ducts. Mental deficiency was often recorded. The intelligence quotient of the patients reported was 33 and 44 respectively. With raised intracranial pressure, headache, vomiting and convulsions, anosmia, blindness and loss of hearing might occur. The etiology was probably an inheritable defect of germ plasm, with consequent aplasia and incomplete differentiation of the skull and other bones.

Surgical treatment of syndactylism might improve the grasp. Osteotomies and wedge-resections of the tarsus might improve function of the extremities. In the cases described, two members of one family had congenital anomalies, but not of the same kind. *Dr R. H. Cram* (Philadelphia) (by invitation) emphasised the importance of early obliteration of the suture lines, which prevented growth of the skull, except by apposition. If a diagnosis were made early, division of the skull in quadrants might permit the brain to develop normally. In the treatment of the syndactyly, the nails might be formed by wedge resection—rather like that for an ingrown toenail. Metatarsus varus was treated by metatarsal osteotomies and Kirschner wire fixation. If the feet were then too wide the fifth toe and its metatarsal might be amputated.

A familial arrested variant of Friedreich's ataxia—*Dr Borden Bachynski* (Regina) (by invitation) described a family of seven siblings, five of whom had a well-marked thoraco-lumbar scoliosis. They presented as examples of a familial idiopathic scoliosis with the primary curve in the thoraco-lumbar region, convex to the right, and also exhibited a partial lateral ophthalmoplegia and a horizontal coarse nystagmus. No other abnormalities of the motor-skeletal and nervous system were demonstrated. The eye changes preceded the scoliosis in all instances. It was concluded that this condition was an arrested variant of Friedreich's ataxia, heretofore underdescribed. The curves were relatively rigid and initial correction was effected with a Risser turnbuckle plaster, modified in recent cases by an extension hinge. The second plaster was applied by the Risser localiser plaster method. When correction was adequate, fusion of the primary curve was undertaken. *Dr T. J. Roulston* (Regina) acknowledged familiarity with the cases upon which the preceding paper was based, and considered that this study separated off a group of cases usually diagnosed as idiopathic scoliosis.

Management of fractures through the middle third of the humerus—*Dr John C. Kennedy* (London, Ontario) had reviewed seventy-eight fractures through the middle third of the humerus, of which 9 per cent were complicated by radial nerve involvement. An anatomical study of the point of entry of the nutrient artery indicated its interruption in a large proportion of cases. Thirty-three of the patients were treated with the hanging plaster; in all these union took place with a good functional result. In the application of the hanging plaster attention was paid to several details; the plaster should be light and it should extend to the fracture site or slightly above it. Open reduction, carried out in 27 per cent of the cases, gave less satisfactory results.

Dr D. C. Johnston (Edmonton) stressed the importance of avoiding distraction at the fracture site, especially if an intramedullary nail were used. These fractures might be treated by any method that avoided distraction. Open reduction was justified in transverse fractures. *Mr M. J. Sharrard* (Sheffield, England) preferred the U-shaped plaster and the collar and cuff, as splinting the fracture more effectively, even when the patient was recumbent. *Dr Borden Bachynski* (Regina) emphasised the importance of maintaining the tone of the muscles of the arm and shoulder by tension exercises to avoid distraction at the fracture and subluxation at the shoulder. *Dr A. E. Trottier* (Victoria, B.C.) preferred a thoraco-brachial plaster with the arm at the side and with the bottom edge of the plaster rolled so that it could be used as a fulcrum and with the forearm supported solely by a collar and cuff.

Hallux valgus and hallux rigidus—*Dr J. C. Favreau* and *Dr Pierre LaBelle* (Montreal) (by invitation) described an arthrodesis performed in thirty-two patients (forty-eight feet involved). A medial and slightly dorsal incision was made over the metatarso-phalangeal joint. The bursa was excised along with a slip of skin. The proximal half of the phalanx and the distal third of the metatarsal were then

exposed. The medial projection and the articular cartilage of the metatarsal head were cut off, but the shape of the head was preserved. A mortise a third of an inch long and a quarter of an inch deep was chiselled on the dorsal aspect of the metatarsal head to receive the base of the phalanx appropriately shaped with a rongeur, and the locked members were further secured by transfixion with stout chromic catgut. A plaster boot was applied with fifteen degrees of extension in men, about twenty to twenty-five in women wearing medium heels, and about thirty to thirty-five degrees in women wearing higher heels. *Dr Ulric Frenette* (Montreal) preferred the McBride operation if the forefoot was hypermobile and spreading without any severe degree of osteoarthritis. He had abandoned arthrodesis because of difficulty in obtaining bony union in a satisfactory functional position. Keller's operation had been used most. *Dr Earl McBride* (Oklahoma City) condemned metallic internal fixation about the big toe, as endangering the circulation. He had simplified the technique of the operation that he had described by grasping the lateral sesamoid bone with a towel clip while dissecting it free. He agreed that arthrodesis was often best, especially for hallux rigidus. *Mr A. G. Quinlan* (Glasgow, Scotland) considered an arthrodesis or an arthroplasty illogical if there was no arthritis. In arthrodesis of the first metatarso-phalangeal joint adequate fixation in good functional position might be difficult to obtain. The technique described might, he thought, present difficulties. The results of effective arthrodesis were excellent.

Juxta-epiphysial metaphysitis in infancy—*Dr D. E. Starr* (Vancouver) asserted that because of the frequency of staphylococcal infection in major hospitals the incidence of acute osteomyelitis in infants remained high. About 90 per cent of fulminating haematogenous osteomyelitis was due to the staphylococcus aureus or streptococcus haemolyticus. Two types were described: 1) with destruction of the entire epiphysis; and 2) with partial destruction and consequent angular deformity. The most severe deformities followed infection within the first few weeks of life. Later correction of angular deformities at the knee involved lengthening of soft tissues, followed by prolonged wedging of plasters until weight bearing on the remaining femoral condyle could be re-established. The preliminary operation might require the excision of the cruciate and collateral ligaments so that the remaining femoral condyle could be shifted on to the tibia. This procedure was preferred to osteotomy. The result was a fibrous ankylosis of the knee, and a brace remained necessary.

The treatment recommended in the acute phase was massive doses of antibiotics. Early drainage was established to diminish epiphysial damage. *Dr A. E. Trottier* (Victoria, B.C.) referred to an increasing incidence of antibiotic-resistant staphylococcus aureus infections in hospitals. Shortening from defective growth after osteomyelitis had been corrected by leg lengthening over intramedullary pins. *Mr Norman Roberts* (Liverpool, England) recommended that, unless there was a good response to antibiotics within twenty-four hours, surgical drainage should be employed, followed by closure of the wound. *Dr R. I. Harris* (Toronto) urged collaboration within hospitals to overcome staphylococcal infection, and recommended a return to the use of antiseptics in the preparation of patients for operation. *Dr J. A. P. Cameron* (Saskatoon) had, in dealing with the septic, unstable hip, placed it in full abduction for six to eight weeks, and then carried out a high femoral osteotomy and Brittain type of graft with the object of arthrodesis. *Dr A. B. LeMesurier* (Toronto) recommended in acute osteomyelitis adequate dosage of several antibiotics and restraint from drainage even if abscesses were present. These had often been observed to absorb, and sequestrated bone had become revitalised. *Dr J. L. McDonald* stated that, since the metaphysis of the upper end of the femur was within the hip joint, it was unnecessary to assume that destruction of the epiphysis preceded invasion of the joint. There was a peculiar tendency at present for epidemics of acute staphylococcal infection to occur at various centres throughout the country.

A clinical and experimental study of plaster-of-Paris bandages—*Dr Edward H. Simmons* (Toronto) and *Dr L. A. Cox* (Montreal) (by invitation) described the clinical evaluation of three experimental plaster-of-Paris bandages by thirty-five surgeons in twelve hospitals across Canada. The evaluation was based on six hundred and fourteen plasters of all types. The experimental bandages differed in such properties as setting time, plaster loss, and the feel of the wet bandage during application. Fast and slow setting bandages were provided. The characteristics of the preferred plasters included rapid saturation, absence of dry spots, low plaster loss, smooth and creamy texture, mouldability, and the absence of skin irritation. In the dry plasters rapid development of strength, durability, freedom from skin irritation, and a white smooth appearance were preferred. About 75 per cent of the doctors preferred a setting time of from three to five minutes; about 25 per cent preferred a slower setting time; many preferred a more rapid setting time for smaller plasters than for larger plasters. Plasters were inspected after removal and tested for strength. These tests were done by wrapping the plaster bandages around cylinders. They were then removed and the crushing strength was measured.

Allowing plasters to crack while setting caused poor crystallisation at the site of the defect. The experimental work suggested that removal of excess of plaster with moderate firmness resulted

in stronger plasters and more rapid strengthening, especially under conditions of high humidity *Dr F. P. Dewar* (Toronto) considered that fast-setting plaster was of value in small plasters in whicl great strength was not demanded, but that in large plasters for scoliotics, and in hip spicas, a slowe setting plaster was more dependable and durable. Before using plaster impregnated with resin i was advisable to question the patient about allergy and phlebitis.

Carpal tunnel syndrome—*Dr W. R. Welply* (Winnipeg) (by invitation) said that the carpal tunne syndrome was far more common than had been generally recognised. Pain might extend to the neck and confuse the diagnosis. When patients supposedly suffering from disc protrusion, cervica osteoarthritis, spondylosis or brachial neuritis did not respond to the regular treatment for these conditions the modified cuff test might be used to confirm the presence of a carpal tunnel syndrome. During eighteen months thirty-six cases of this syndrome were recognised, and in twenty of these the flexor retinaculum was divided. The skin was divided transversely just above the wrist and the retinaculum longitudinally. A modification of the Gilliat and Wilson sphygmomanometer test was described. First a sphygmomanometer cuff on the upper arm was inflated to a pressure above the patient's systolic pressure; after two minutes the pressure was reduced to a level between the systolic and diastolic pressures, commonly between 80 and 100 millimetres of mercury. A positive result was indicated if tingling or pain first occurred in the distribution of the median nerve, where it was often severe. A control subject might have pins and needles in the hand during the test, but usually in the little fingers first. Of twenty patients subjected to the operation, eighteen had complete relief of pain. *Dr Cameron Allen* (Vancouver) had seen nine cases, two of which had come to surgery. One of these followed a Colles's fracture. He believed that flexor tenosynovitis was one of the underlying conditions. The patients not subjected to surgery had made a symptomatic recovery. *Dr William Thompson* (Vancouver) considered that a more complete exposure should be made before the retinaculum was divided. *Mr J. S. R. Golding* (Jamaica, B.W.I.) emphasised that the pain might not be well localised in the median distribution, especially as it became more severe. A transverse skin incision at the wrist was preferred, with a longitudinal incision overlying the palmaris longus, which could then be divided. The tissues immediately overlying the median nerve were divided over a McDonald's raspatory. The incision might be extended if it was found that flexor tenosynovitis was the underlying cause.

Bone changes in haemophilia—*Dr R. N. Lofthouse* (Hamilton) said that the incidence of haemophilia was estimated at 1 in 10,000 in North America and 1 to 2 per 100,000 in the British Isles. It was not found in coloured people except the Japanese.

The haemophiliac syndrome was fully developed in early childhood, and the family history was of a typical Mendelian sex-linked recessive character carried by the female and present in the male. The prolonged coagulation time was associated with defective thrombin formation. Haemophilia was first described by Otto in 1803. The joint changes were described in detail by the late J. Albert Key in 1932. Radiographs showed increased density of the synovial tissues from the deposition of iron pigment. There might be punched-out areas over the joint surface. The joint space was narrowed and the intercondylar notch deepened and widened. There was also bone atrophy, and in the later stages osteoarthritis. A boy aged fourteen years had a swollen right fourth finger, and radiographs showed almost complete destruction of the proximal phalanx and similar but lesser changes in the fifth metacarpal bone. Metacarpo-phalangeal disarticulation was performed; the wound healed slowly, and bleeding was not a problem. Electro-coagulation aided haemostasis, and gelfoam provided a suitable haemostatic dressing. The gross and microscopic appearances were demonstrated. The changes in this case were primarily in bone, and were not a complication of a haemophiliac joint. *Dr Louis-Philippe Roy* (Quebec City) stressed the changes that occurred more commonly in haemophilia. *Dr J. A. P. Cameron* (Saskatoon) presented slides to illustrate a case in a twelve-year-old boy who, from the age of two or three months, had bled from various sites. The lower limbs were spastic, and stroking the legs provoked a mass reflex. Dr Cameron reported a relatively high incidence of haemophilia in the Malay population.

Injuries to the cervical spine—*Dr W. J. Thompson* (Vancouver) presented a series of twenty-eight cases demonstrating early and late sequelae of injury to the cervical spine. He emphasised the need for careful handling after injury. For fracture-dislocation, skeletal traction with Crutchfield tongs was instituted early. When paralysis or pain persisted, operation was necessary; it might entail laminectomy, reduction of displaced facets, reduction of the fracture and wiring the unstable vertebra with stainless steel wire. Operation was employed in eight cases; it simplified management and often caused symptomatic improvement. A late review showed that stability had been obtained without serious interference with mobility. *Dr Moss Albert* (Lethbridge, Alberta) said that the problem of turning patients with cervical injuries has been much simplified by the Stryker frame. Immediate manipulative reduction of fracture-dislocations often proved them to be unstable, and skeletal traction

was favoured. Locking of the articular facets called for open reduction and fixation of the spinous processes. In cases with complete and immediate tetraplegia skeletal traction was employed, and anticoagulants were given with the object of preventing thrombosis of spinal as well as peripheral veins. *Dr F. P. Dewar* (Toronto) ascribed pain in these cervical cord injuries, especially with tetraplegia, to three possible causes: occasionally cord damage, sometimes root damage, or damage to soft tissues and joints. It was pain from the last cause that responded best to fusion, especially if there was instability. If immobilisation and traction failed to relieve pain, fusion was unlikely to do so.

Recurrent anterior dislocation of the shoulder joint—*Dr W. B. MacKinnon* (Winnipeg) had studied forty-nine consecutive cases of recurrent anterior dislocation of the shoulder, dealt with during eleven years by the Bankart operation, or its modifications, or, in the seven cases in which no Bankart lesion was found, a Putti-Platt operation. There were three instances of recurrence, in all of which a full range of movement had returned. In all other cases lateral rotation was limited by fifteen degrees or more. The best appearance followed an incision running in Langer's lines from the clavicle over the coracoid process to the apex of the axilla. The end-results were demonstrated by means of a moving picture. *Dr A. S. McConkey* (Vancouver) recalled that radiographs might demonstrate those cases with a large defect in the humeral head. The Kocher manoeuvre for reduction might injure further the humeral head and full lateral rotation might be unnecessary in order to achieve reduction. Three weeks might be the best time for immobilisation after reduction. *Dr Charles Hollenberg* (Winnipeg) aimed at a full range of movement of the shoulder after Bankart's operation unless there was a large defect in the humeral head or in the anterior rim of the glenoid. *Dr H. H. Boucher* (Vancouver), having observed recurrences when a full range of movement had followed operation, now preferred some limitation of lateral rotation.

Recurrent instability of the ankle—a method of surgical treatment—*Mr David L. Evans* (London, England) recorded a study of fifteen women and four men with recurrent instability of the ankle treated by transposition of the peroneus brevis tendon. The average age of these patients was thirty-four years. Each gave a history of an original acute sprain, after which, at an interval of weeks to years, the ankle gave way and " went over " inwards. The only constant clinical finding was increased passive inversion. Radiographs revealed tilting of the talus within the ankle mortise. An operation for transposition of the peroneus brevis tendon was described. Through an incision behind the fibula the peroneus brevis tendon was defined. It was divided at the upper limit of the incision, dissected free, and withdrawn through the superior peroneal retinaculum to a point below and in front of the lateral malleolus. A hole was drilled diagonally forwards and downwards through the lower end of the fibula. The tendon was threaded through the drill hole, and, with the foot held in slight eversion, reattached to the proximal end and overlapped. After closure of the wound, a below-knee plaster was applied, with the foot at right angles and in the mid-position. After three weeks a walking plaster was applied. At the end of another three weeks this was removed and normal walking initiated. Follow-up examination of fourteen patients, three and a half to eight months after operation, revealed some limitation of inversion of the foot. In some, the transposed tendon could be seen and felt acting above and below the fibular tunnel. In others a tenodesis had resulted. The time off normal duties averaged two months. The results in twelve cases were good with no recurrence of instability or other symptoms. Post-operative deep vein thrombosis occurred in one case; in another there was some pain and swelling and marked restriction of inversion of the foot. *Dr Olav Rostrup* (Edmonton) recommended that severe acute sprains of the ankle be treated in plaster, with the foot in slight eversion. *Dr H. Coleman* (Toronto) asked Mr Evans if he had encountered patients with a story of recurrent dislocation about the ankle, who apparently had dislocation occurring at the subtalar joint. It was suspected that this condition existed. *Dr I. W. Davidson* (Sudbury, Ontario) suggested a radiological criterion for subluxation of the ankle. With the patient under a general anaesthetic the foot was strongly inverted and antero-posterior radiographs were taken. Lines were drawn along the lower articular surface of the tibia, and the upper articular surface of the talus. If these lines came together within the substance of the medial malleolus, pathological dislocation was present. In these cases plaster immobilisation was employed for six to eight weeks. *Dr F. P. Patterson* (Vancouver) agreed that subtalar subluxations did occur. The method of Watson-Jones has been successfully used for the control of recurrent subluxation at the ankle joint. The method of Dr C. Hague of Vancouver, B.C., in which the distal tibio-fibular ligament is transferred, was also recommended.

An experimental study of accelerated consolidation of fractures—*Dr Leo Jarry* (Verdun, P.Q.) and *Dr Hans-K. Uhthoff* (Montreal) (by invitation) had made an experimental study of the acceleration of bone callus formation on 428 white rats, in which operations were performed on the left and right tibiae, followed by immobilisation. Both bones were fractured in a similar manner. The left tibia was used as a control while the right was surgically modified by the " petals " method, " petals "

being cut from the cortex in such a manner as to leave their bases still attached by bone. This technique was applied only to the antero-medial and antero-lateral aspects of the tibiae. About eight " petals " were cut on each side. The " petals " were cut one-quarter of an inch from the fracture site in 278 rats, and the paper is based on the results in these.

The incision extended from the middle to the lowest third of the leg, and the tibia was divided by a scalpel at about the mid-point of this wound. Immobilisation was achieved by the insertion of an intramedullary Kirschner wire. The fibula was resected in order to avoid any possible influence that its callus might exercise on the callus formation of the tibial fracture. The rats were killed on the twelfth, twentieth, thirtieth and fortieth day after operation. The Kirschner wires were then removed, radiographs were made and the tibiae were suspended and tested for the breaking point by means of a fine metal wire looped over the fracture site of each and the application of weights to a suspended receptacle.

After twelve to twenty days the experimental and control procedures showed no significant difference. After thirty days the " petal " technique began to give better results than the conventional procedure, and after forty days there was a very marked difference in favour of the " petal " procedure.

The results were checked statistically by the Director of the Centre of Statistics, the University of Montreal. When the Kirschner wire was removed thirty-one to thirty-six days after setting the fracture the body weight in 50 per cent of all cases produced bending of the left tibiae which were treated conventionally, whereas the " petal " tibia showed superior strength.

Radiological examinations showed that the decalcification and revitalisation of the cortex was always more pronounced on the " petal " side. Histological findings indicated that the formation of the anchoring callus took place much closer to the fracture site if the " petal " method was applied. Decalcification in the region of Haversian canals took place earlier; likewise the revitalisation of these canals was accelerated. *Dr R. I. Harris* (Toronto) complimented the authors on their ingenuity. The cutting of the " petals " diminished the thickness of the cortex, and therefore diminished the time required for revascularisation. An increased surface was provided. He asked whether, after forty days, the bone would sometimes break at some other site. It seemed that in the controls union was obtained through organisation of a large subperiosteal haematoma, and that in the experiment union was augmented by the formation of an overlying graft. *Dr Hans Uhthoff* replied that after forty days the bone would break in the same place, but that after fifty days it would sometimes break near the old fracture site. *Dr Leo Jarry* did not agree that the technique constituted a graft, because no bone was added to the fracture site.

Mechanics of disc physiology as related to early stages of disc degeneration from the clinical aspect—*Dr W. H. Fahrni* (Vancouver) cited intervertebral disc lesions as the cause of back pain in at least 90 per cent of cases. The treatment of intervertebral disc lesions by operation had caused a number of bad results, and had led to a closer scrutiny of the intervertebral disc in its relation to back pain. In the erect stance of the biped the lumbar spine was forced into lordosis, which weakened it mechanically and subjected the intervertebral disc to adverse strains. Following the teaching of Williams, the treatment of back pain and sciatica by flexion exercises was developed. The axis of movement of the intervertebral disc lay in the posterior half, but the normal excursion remained to be defined. In elderly patients it was the posterior part of the disc that showed evidence of degeneration. In scoliosis disc degeneration was most evident on the concave side of the curve. Extra-spinal symptoms from anxiety were often associated with low back pain, often because the patient dreaded the possible economic effects of his disability. " Growing pains " in children might be the result of abnormalities of the intervertebral discs, and might be heralded by associated tight calcaneal tendons and hip flexion contracture. In these instances it might be found that the real limitation of movement was in the lumbar spine. Exercises to mobilise the lumbar spine might relieve these symptoms, and must be continued for several weeks or months. This condition might be regarded as an early stage of disc degeneration. In older children back pain might be found associated with a short leg and its associated scoliosis. Compensation of the discrepancy would often relieve the pain. Pain was felt on the side of the long leg almost invariably. When it was found on the side of the short leg one could be sure that it had nothing to do with the scoliosis and that other causes must be sought. Some degree of disc degeneration was likely. Malposture associated either with thoracic kyphosis or lumbar lordosis might also be associated with disc degeneration, bulging of the discs causing traction on the intervertebral ligaments, and consequent pain. Postural exercises to correct the malposture, and a flexion plaster in a few cases, might bring relief. Adults with minimal low back pain and hip and leg pain, without physical findings, might have sufficient disc degeneration to require treatment. The great variety of symptoms in the upper and lower extremities, cervical region and back, might come from minor degrees of disc degeneration. The early recognition and treatment of disc degeneration was emphasised.

Dr Charles Hollenberg (Winnipeg) stated that, on flexion, the anterior part of the disc space became narrowed and the posterior part became widened, and that the reverse occurred on extension. The posterior part of the annulus was subjected to a greater strain than any of the ligaments behind it. The most acute and recurrent episodes of low back pain occurred in forward flexion, as in picking something up from the floor. The dachshund was subject to acute attacks of disc herniation with paraplegia, and this usually occurred in flexion. Many people with disc degeneration, as shown by radiographs, had no symptoms. The presence or absence of symptoms depended upon the area of degeneration and the effect of strain upon it. *Dr John Cooper* (Hawaii) had carried out discography by introducing radio-opaque fluid through a fine needle into a lumbar intervertebral disc space in 400 patients in five years. It often caused excruciating pain in the affected disc space and would often reproduce the pain of which the patient had complained. Valuable information has been obtained in a number of instances of obscure pain.

ASSOCIATION MEETING 1957

The orthopaedic surgeons of Quebec City were hosts to the Thirteenth Annual Meeting of the Canadian Orthopaedic Association, held on June 27–30 and July 1, 1957. Under the presidency of Dr Louis-Philippe Roy the Association met for a clinical session at the L'Hôpital de L'Enfant Jésus and the following day embarked upon the river steamer *Tadoussac* for the Manoir Richelieu, Murray Bay.

The Association was most grateful to and delighted with its guests, Professor Robert Judet of Paris and Professor Carl Hirsch of Upsala, for their keen participation in the discussion and their studied contributions to the programme. Dr Robert Lofthouse, Canada's current nominee to the A.B.C. Club, reintroduced to us persons long held in respect and friendship, by a superb and well illustrated travelogue. Perhaps the highlight of the meeting was the President's address. He traced through history the slowly changing pattern of French-English relationships in Canada and remarked upon the recent though relatively important role played by our Association. He concluded by stating that the period of integration was almost over and that all of us now wished to be thought of as Canadians with no further distinction.

Clinical meeting l'Hôpital de l'Enfant Jésus, Quebec City—A spirited discussion on malignant growths was stimulated by a group of case presentations dealing with **multiple myeloma** (*Dr Jean Lemieux*), **synovial sarcoma** (*Dr J. L. Larochelle*), **osteogenic sarcoma** (*Dr V. Laperriere*) and **hind-quarter amputation** (*Dr E. Lepine*). The debate presented the well-recognised form of treatment as opposed to the somewhat more gentle and less radical operation of local excision and prosthetic replacement.

Paget's disease of bone (*Dr J. M. Lessard*) in many of its bizarre manifestations was well illustrated and difficulties of early diagnosis were emphasised. Biopsy proved to be a valuable assistant.

Other case reports included **Milkman's syndrome** (*Dr G. Morissette*), **multiple congenital deformities** (*Dr J. Leclerc*) and **Blount's disease** (*Dr L.-P. Roy*).

An unusual problem of **unilateral intracranial protrusion of the condyle of the mandible** (*Dr J. P. Roger*) after injury caught the attention of the audience. Delivery of the condyle by manipulation was impossible. This was successfully achieved at operation by dividing the condylar neck. The patient has done well since.

The afternoon was free for golf or sightseeing, no easy choice for those familiar with the delights of the Quebec scene. Only the executive were confined indoors, although their confinement was alleviated by the discovery that their prison was the Vice-Regal Suite of the Château Frontenac and that Dr J. L. McDonald was the turnkey. Wining and dining and folk dancing dissipated the evening and afforded the members an opportunity to thank their gracious hostesses, the wives of the orthopaedic surgeons of Quebec City.

Spondylolisthesis in children—*Dr J. M. McIntyre* (Montreal) spoke of two groups. In congenital spondylolisthesis there was usually much slipping because the sacral facets were rudimentary, and diagnosis was easy because of the great lumbar lordosis, often associated with scoliosis; other congenital anomalies were common. In acquired spondylolisthesis, usually related to injury, there was minimal slipping. From a study of the literature, supplemented by his own ten cases, the author concluded that conservative treatment was of limited value and that removal of the loose lamina might relieve nerve root pain but did nothing for the instability; he recommended spinal fusion after removal of the loose arch. No evidence of a fibrocartilaginous mass was found in association with the pseudarthrosis.

Leg-lengthening operation—*Dr J. Calixte Favreau* (Montreal), paying tribute to Mr M. V. Anderson of Princess Margaret Rose Hospital, stated that he had brought nine cases to successful conclusion

since his visit to Edinburgh in 1952. The indications for, and technique of, the operation as described by Mr Anderson were followed implicitly and few complications were encountered. The arguments for and against such a procedure were clearly stated.

Recurrent dislocation of the patella—*Dr F. P. Dewar* and *Dr J. E. Hall* (Toronto), having encountered some of the difficulties of tibial tubercle transplantation, recommended Galeazzi's operation of semitendinosus tenodesis altered only by passing the tendon through the lower pole of the patella. Their short experience had been encouraging and the long-term studies from Italy more so. This operation, not practised on this continent, was easy and worthy of consideration.

Fusions about the talus in children—*Dr W. T. Mustard* and *Dr C. A. Laurin* (Toronto) reviewed 209 cases. Extra-articular subtalar fusion (Grice) was easily and safely obtained at five years of age. The operation maintained subtalar alignment after correction of the deformity and was performed at a young age to discard a brace. After eight years of age fusion was best deferred until triple arthrodesis was possible. Triple arthrodesis should not be performed until twelve years of age. Over-correction was rare, and recurrence of the deformity was common unless the muscle imbalance was corrected at the same time. Lambrinudi's operation provided a good correction of idiopathic pes cavus but should not be used for paralytic cavus. A weak calf was considered a contra-indication but in cases of dynamic fixed equinus the results were good. Ankle fusions were rarely indicated for paralysis in children. A Gallie fusion could be performed without disturbing growth. Pantalar arthrodesis gave excellent results when the leg below the knee was flail. The danger of genu recurvatum was minimal when hamstring function was good.

Sterilisation of homogenous bone grafts by beta proprio lactone (B.P.L.)—*Dr A. M. Wright* (Montreal) recognised the difficulty of obtaining large quantities of bone for a bank under sterile conditions. He avoided this problem by disregarding the circumstances under which the bone was gathered and by sterilising the bone in a solution of beta proprio lactone. The grafts were then stored and used without mishap in a large series of experiments. The grafts behaved like those stored by other methods. The author felt that the tests were sufficiently advanced to warrant clinical application.

Compensable low back disabilities—*Dr J. L. Johnston* (Toronto). The Chief Medical Officer of the Workmen's Compensation Board of Ontario said that the work histories of 1,300 patients with low back pain, with or without sciatica, had been reviewed. Seventy-five per cent of the patients returned to the same type of work though they were disabled for an average duration of six months. Conservative treatment succeeded more often than operative. Of patients treated by operation, 43 per cent returned to the same occupation, 20 per cent to heavy work and 23 per cent to light work. There were very few that had not returned to work at all.

Clinical assessment of low back pain and sciatica—*Dr Carl Hirsch* (Upsala) reviewed the whole problem, using the wide experience of his associates and himself comprising several thousand cases. At least 60 per cent of the population suffered this disability during their lives. The highest incidence lay in the years thirty to fifty. Sex and occupation were not predisposing factors, though heavy workers were more incapacitated than those in sedentary pursuits. Herniations of the nucleus were by far the commonest cause of the distress, and were best diagnosed by myelograms using a water-soluble contrast medium given in conjunction with a spinal anaesthetic. In some 10,000 uses of this material no serious complications had been encountered. Immediate operation was the treatment of choice for proven herniations and was not accompanied by spinal fusion. Conservative therapy with rest and braces or plaster was found to result in recurring and prolonged disability.

Pott's disease in children—*Dr W. B. MacKinnon* (Winnipeg) recounted the experience of the surgeons of St Boniface Sanatorium, the late Dr A. B. MacKinnon, the late Dr Henry Funk and himself. Forty children were treated in the last twenty-five years. The advent of antibiotic therapy had abolished amyloid disease and had reduced the mortality to nil. It was evident that spinal bone grafts, even in young children, would grow with the child and would not create or increase pre-existing deformity.

Pyogenic osteomyelitis of the spine—*Dr J. W. Hazlett* (Kingston, Ontario) reported forty cases, twenty-nine probably being haematogenous. The genito-urinary tract was condemned as a frequent source of infection. Diagnosis was difficult and was assisted by aspiration and biopsy. Treatment was specific and cure usually resulted without recourse to spinal fusion.

Gritti-Stokes amputation—*Dr F. R. Tucker* (Winnipeg) said that, at the age of twenty-nine, a hundred years ago, Gritti first described the operation though he had never performed it upon a living person. The operation was popularised by Sir William Stokes, a Dublin surgeon, consultant to the British Forces in South Africa. He modified the operation slightly. The author reviewed fourteen long-term

follow-up cases and concluded that the stump was durable, the gait generally good and the work histories of the patients quite remarkable.

"Petals" versus bony transplants in treatment of experimental pseudarthrosis—*Dr Leo Jarry* and *Dr Hans Uhthoff* (Verdun, Quebec) said that the term "petal" described a chip of bone raised from the cortex adjacent to the fracture in such a manner as to leave its base attached. This produced an increased area of contact at the site of a fracture of a long bone. This experiment carried out on rats suggested that in artificially produced pseudarthroses the cutting to petals was a more certain method of producing union than the onlay graft.

A method of repairing chronic dislocation of the acromio-clavicular joint—*Dr D. G. McFadden* (Kitchener) described a procedure comprising resection of the lateral part of the clavicle and by means of a drill-hole replacement of the torn coraco-clavicular ligament by the coraco-acromial ligament.

Cavernous angiomata in the muscles of the extremities—*Dr E. S. James* (Winnipeg) said that cavernous haemangiomata, probably congenital, were seen in young persons, one half of the patients being under the age of ten. Pain and swelling were the presenting symptoms. The tumour was not malignant and was cured by adequate excision. Five cases were reported.

Spontaneous fracture of the femoral neck after deep x-ray treatment—*Dr D. L. MacIntosh* (Toronto) described twenty-three cases. Pain was usually the presenting symptom, and the first radiograph was often negative. The fracture would appear in a few weeks. The fractures showed a strong tendency to heal. It was hoped that routine use of the cobalt bomb, with its much lower coefficient of absorption in bone, would make rare this complication of the treatment of pelvic malignant disease.

Fracture-dislocation of the body of the talus—*Dr D. E. Starr* (Vancouver) recalled that posterior dislocation of the body of the talus is seldom, if ever, amenable to manipulation, and advocated open reduction by a postero-medial incision and retraction of the malleolar fragment that usually results from the original injury. Avascular necrosis was a common, if not certain, sequel. Weight bearing was allowed when the fracture was united, and no cases showed collapse of the body. Nine cases were reviewed in detail.

Blood supply of the tibia—*Dr I. Macnab* (Toronto) had studied the blood supply of the shaft by injection techniques and by animal experiments. In the resting state the nutrient system, freely anastomosing with the metaphysial vessels, comprised the major source of blood supply. The main venous drainage was through the periosteal vessels, and the nutrient vein was always smaller than the nutrient artery. However, with a fracture, the periosteal supply assumed a prime role because the endosteal supply was divided. Fractures would heal without endosteal circulation but never without periosteal circulation. Such physiological considerations were particularly important in the management of fractures by open reduction.

The use of Henry's hinge graft—*Dr Roger Gariepy* (Montreal) demonstrated in fourteen cases the use of Henry's ginglymus implant to limit excessive movement at a paralytic joint, thus leaving a modicum of movement rather than a solid fusion. A graft might hypertrophy and be visible in the radiograph as an obvious pseudarthroses, or it might de-ossify, persisting only as a ligament. Some successful results and some failures were shown.

Hip fusion after failed prosthesis—*Dr G. W. Armstrong* (Ottawa) showed a successful method of solving this troublesome problem by mortising the remaining neck and trochanter into the upper acetabular rim.

Hip prostheses—*Dr Robert Judet* (Paris) reported good results in 67 per cent of operations with the old type of prosthesis used before 1952 and in 72 per cent with the new oblique prosthesis—1,217 cases in all. Atrophy of the neck of the femur and loosening about the stem occurred commonly with the old type and was uncommon in the new series, as the oblique prosthesis accepted the stress of weight bearing more advantageously. The problem of acetabular necrosis and cyst formation remained unsolved. There was only one case of broken prosthesis in the whole series. Dr Judet saw no indication for the use of the long-stemmed intramedullary prosthesis, which he considered to close the door on most further methods of reconstruction.

Surgical treatment of chronic arthritis of the hip—*Dr J. E. Samson* (Montreal) reviewed 109 cases. Good to excellent results were obtained in 95 per cent of arthrodeses, 37 per cent of cup arthroplasties, and 50 per cent of replacement arthroplasties. He favoured arthrodesis if only one hip was involved. In bilateral cases he advised arthrodesis of the worse hip, accompanied if necessary by a plastic procedure on the other. Cup and prosthetic arthroplasties were performed only as a last resort.

Central dislocation of the hip joint—*Dr G. F. Pennal* (Toronto) had found among 200 fractures of the pelvis involvement of the acetabulum in twenty-eight cases, ten of these by central dislocation whether stable or unstable. In stable cases the posterior acetabular fragment was large and the dislocation was somewhat posterior; they could be reduced and maintained by light traction. Unstable fracture-dislocations tended to be more anterior and were very comminuted; they might be reduced by manipulation and traction, but the fragments did not follow the head and redislocation occurred with release of the traction. These fractures were amenable to open reduction. The approach was anterior and extra-peritoneal. The fragments were manipulated into position under radiographic control with the legs fixed in strong traction. Internal fixation with screwnails was often desirable. The results in five cases of open reduction were most satisfactory.

Central dislocation of the hip joint—*Dr C. L. Wilson* (Montreal) demonstrated on a prepared anatomical specimen that these cases were not true central dislocations but fracture-dislocations, with a large postero-superior fragment that was displaced posteriorly and medially by lateral rotation of the leg. The fracture could easily be reduced by a posterior approach and held by internal fixation and this had been verified clinically. The radiographic appearance of protrusion of the acetabulum was largely due to the postero-medial displacement of the large fragment of the pelvis.

CANADIAN JOURNAL OF SURGERY

For some years the surgeons of Canada have felt the need for a national journal in which they could publish their own original work. Last year the leading surgical groups in Canada met and requested the Canadian Medical Association to undertake the publishing of a quarterly *Canadian Journal of Surgery*. The Association gladly agreed to cooperate in this, and it is announced that the first issue of the *Canadian Journal of Surgery* will appear on October 1, 1957. The Editorial Board consists of the professors of surgery from the twelve Canadian medical schools, with Dr R. M. Janes of Toronto, President of the Royal College of Physicians and Surgeons of Canada, as chairman of the Board. Publication will be under the general supervision of the Editor of the *Canadian Medical Association Journal*.

This Journal will carry original articles, case reports, editorials, and book reviews in the two official languages of Canada—French and English: original articles in English will carry a summary in French, and vice versa. The historical section will feature the history of Canadian surgery. Subscription has been set at $10.00 for the first year.

CHINA

ORTHOPAEDIC SURGERY IN MODERN CHINA

A party of twenty Australian medical men was invited recently to visit China and examine the standards and methods of medical training and practice there. In the party there were professors of some of the preclinical subjects and public health, and also physicians and surgeons representing the common specialities. We entered China via Hong Kong, spent a few days in Canton, and then travelled north by train. We stayed three days in Hangchow, a week in Shanghai, and ten days in Peking including a visit to Tientsin. We were able to visit six of the thirty-five medical schools now established in China and about twelve hospitals in the main cities. Many of these had been recently built or greatly enlarged.

Even to an orthopaedic surgeon the most striking advances are in public health. We saw no flies and very few mosquitoes. We were told that the great pestilences—plague, cholera, typhus and smallpox—have been suppressed, and that much progress has been made in controlling typhoid and malaria and in reducing infant mortality. Tuberculosis and schistosomiasis remain great problems. We saw no case of malnutrition and very few physically handicapped children.

In the main centres the standard of surgery is high and all the common orthopaedic procedures seen in British or American hospitals are carried out. Many of the senior surgeons have been trained in the United States or Europe, and most speak English well. Both in Shanghai and in Peking I met about twenty surgeons whom I understood to be practising orthopaedic surgery alone. The hospitals have excellent libraries and the *Journal of Bone and Joint Surgery* is widely read. The library of the Chinese Union Medical College, built in 1917 by the Rockefeller Foundation and now a postgraduate hospital, has 1,100 current journals, and the Academy of Medical Sciences in Peking takes 1,300 journals. Since the advent of the present government in 1949 few of the surgeons have been out of China but there have been visiting medical delegations from about twenty countries.

The senior orthopaedic surgeon in Shanghai is Y. C. Yieh, who gained his M.Ch.Orth. in Liverpool in 1936. He has kept the Liverpool tradition very much alive, and in spite of his isolation from the western world he has kept abreast of all modern advances. For example, he had recently performed twelve antero-lateral decompressions for Pott's paraplegia. He is now helping to write a text-book in Chinese, and is especially interested in the history and practice of orthopaedics in ancient China. In a recent publication he has reviewed many old manuscripts dating back even to the second century A.D., in which some of the methods still used in treating traumatic cases are described for the first time. When published and translated this work should be of great interest to all orthopaedic surgeons.

In Peking orthopaedic surgery is under the direction of C. M. Meng, a pupil of Steindler. Most of the patients are concentrated at the new Peking People's Hospital, where J. S. Horn, previously at the Birmingham Accident Hospital, is helping on the traumatic side. Other hospitals, including the Chinese Union Medical Hospital, have a limited number of beds mainly for short-term orthopaedic cases. At the Chinese Union Medical Centre we were shown the remarkable case of a Siamese twin over seventy years old who had been separated from his dying brother the previous night. They had been attached by the lower end of the sternum and the upper part of the peritoneal cavity, and had wives, children and grandchildren. A week later the survivor was out of bed and appeared to be doing well.

In the wards there is a noticeable paucity of accident cases because of the small number of cars in the cities. Beds so gained are lost to cases of bone and joint tuberculosis. The incidence of many other disorders differs widely from that seen in British communities. For example, most diseases of the hip—including congenital dislocation, Perthes' disease, slipping of the femoral epiphysis, and even osteoarthritis in old age—are extremely rare. Paget's disease is a curio. In contrast to the Malayans and Indonesians, the Chinese seemed to suffer from disc degeneration and sciatica fairly commonly. Antibiotics are freely available and widely used. The incidence of post-operative infection is very low; about one in five hundred elective orthopaedic operations, I was told. These include cases of tuberculosis and many cases of grafting with banked bone. The strains of penicillin-resistant staphylococci which provide us in Australia with our greatest surgical problem have not yet developed there.

The most impressive work seen was the radical surgical treatment of bone and joint tuberculosis performed under cover of streptomycin. This may have been inspired by the work of Wilkinson in England but has been taken much further. Cases were seen in all hospitals, but the largest collection was at the People's Hospital in Tientsin under the charge of H. C. Fang. This hospital has 270 orthopaedic beds including seventy beds for bone and joint tuberculosis. In addition to the routine surgery the staff publish a small bulletin every month, carry on research with animal experiments, maintain an instrument shop and have moving pictures in colour of some of their operations. The radiographs were of poor quality by our standards. Patients are given streptomycin for two or three weeks and then an attempt is made to remove all infected tuberculous tissue. In the case of hip disease the head of the femur is dislocated and all the capsule and synovial membrane as well as diseased bone is removed. In early cases good function is usually regained; in late cases there is quick fusion. Many patients with Pott's paraplegia have been treated successfully by decompression of the cord. The operation is done under induced hypotension; the spine is usually fused and decompression is sometimes carried out on both sides. They have recently reported the results of 941 cases of bone and joint tuberculosis treated by radical excision of the tuberculous focus. These include 193 hips, 428 spines, 198 knees, eighty-six elbows and thirty-six sacro-ilac joints. Of patients with hip disease, 95 per cent have either got fusion or a mobile joint with no evidence of recurrence after an average stay in hospital of seven and a half months. Of patients with tuberculosis of the spine with cord compression 61 per cent have been " cured " with an average stay in hospital of 11·6 months. The follow-up in some instances is short, but the patients seen confirmed the excellence of the reported results.

Other conditions can be mentioned only briefly. Fractures of the neck of the femur were less common than in western communities. Most hospitals made their own three-flanged nails from stainless steel. Pertrochanteric fractures were usually treated by traction alone, but fractures of the shaft of the femur were often fixed with intramedullary nails, also made locally. There was a healthy difference of opinion between radical and conservative forms of treatment for most of the common fractures. Paraplegics were seen in good condition without bedsores. Manipulation for backache was generally frowned upon, but patients with resistant disc prolapse were subjected to laminectomy, usually combined with spinal fusion. Because of the Chinese habit of squatting, arthrodesis of the hip is avoided if at all possible. The commonest type of arthroplasty seen was the Batchelor type. They also use a metal cup occasionally but have had no experience with acrylic or Vitallium prostheses. No case of degenerative osteoarthritis of the hip was seen; the arthroplasties had been performed

for ankylosing spondylitis or advanced rheumatoid arthritis. The bone bank was extensively use
for ununited fractures, and fusion of spines with scoliosis. One case of hind-quarter amputatio
for sarcoma of the buttock and several cases of excision of congenital discoid lateral cartilages we
among the other cases seen in the wards. The last condition appears to be unusually common amor
the Chinese.

The object of the government is to train and graduate enough doctors to serve China's populatio
of 600,000,000. To meet this emergency the medical course has been shortened to five years an
46 per cent of the students are now women. Those specialising in surgery spend four further yea
in hospital under supervision, and there are facilities for postgraduate refresher courses. We visite
only the chief medical centres in the large cities. From these centres new units are being formed
serve further afield. Much has been achieved already but the leaders of the profession are conscio
of the enormous task that still lies ahead. They have the responsibility of maintaining their prese
standards and of training new teachers for the many medical schools and hospitals that have y
to be built.

HUGH BARRY.

ANNOUNCEMENTS

MATERIAL FOR CLINICAL RESEARCH

The Editorial Board has agreed to make space available in the Journal for the publication of requests from individual surgeons who wish to collect reports of uncommon disorders for speci study. Any reader who has material related to the subject mentioned below and who is willing to pass it on for the common interest is asked to communicate with the Editor, or directly with the surgeon concerned.

Fibrocystic lesions of bone—*Mr R. Owen*, of the David Lewis Northern Hospital, Leeds Street, Liverpool 3, is conducting a survey of the clinical and pathological aspects of: 1) local forms of fibrous dysplasia of bone; 2) simple bone cysts; and 3) ill-defined lesions bordering on the above conditions. The objects of the survey are to determine: 1) The natural history of the conditions. 2) The relationship, if any, between fibrous dysplasia of bone and simple cysts, and the possibility that a few examples of so-called aneurysmal bone cysts might come within this orbit. 3) Determination of the recurrence rate and corellation of these with the various methods of treatment used. 4) The probability of arriving at a satisfactory histological grading. This aspect of the work will be studied in conjunction with a morbid anatomist of repute.

AMERICAN SOCIETY FOR SURGERY OF THE HAND

The thirteenth annual meeting of the American Society for Surgery of the Hand will be held at the Waldorf-Astoria Hotel in New York City on Friday and Saturday, January 31 and February 1, 1958.

Book Reviews

ARTIFICIAL LIMBS IN THE REHABILITATION OF THE DISABLED. By R. D. Langdale KELHAM, *O.B.E.*, F.R.C.S., with six other contributors, Medical Officers of the Ministry of Health Limb Service, Roehampton. $9\frac{3}{4} \times 6\frac{1}{4}$ in. Pp. vii + 188, with 58 figures. 1957. London: Her Majesty's Stationery Office. Price 20s.

There can be few surgeons who have visited " Roehampton " during the last thirty years who have not said, on taking their leave of Langdale Kelham: " You ought to write a book . . ." Only after his official retirement has Kelham found the time to do so, ably assisted by the several limb-fitting surgeons now needed to man the greatly expanded service.

Here we have, within a most convenient compass, the whole of the technique and technology of British limb-fitting, ranging from details of manufacture, through the prostheses available and the indications for their individual use to the final approval of the completed limb and the rehabilitation, re-education and occupational resettlement of the patient. Much emphasis is placed on the psychological problems associated with the loss of a limb and very helpful advice is given. On a slightly less elevated plane a short chapter appears on stump ailments, but only those are included which normally enter the ken of the limb-fitting surgeon.

The illustrations (some of which are familiar to readers of this Journal) are of variable quality and are grouped together at the end. It would, perhaps, have made the descriptions of the limbs easier to follow if the relevant pictures, and more of them, were interspersed. This is not a literary work and the idiom of the Limb Centre continually obtrudes, but it is very much more than a catalogue and is clearly intended as a reference book. As such, it will often call for new editions as improvements in artificial limbs arise, when opportunity might be taken to give it more polish, to improve the references and to add an index. We hope that we shall see in the future descriptions of " anatomical " sockets for other sites than the above-knee stump and the news that the difficulties interfering with the more extensive use of the durable plastics have been overcome. Finally, a word of acknowledgment of the work of A. J. Craft in the early days of the Research Department, and in particular in the development of the anatomical socket and the resuscitation of the suction socket, might not come amiss.

It is, in the upshot, a brilliant achievement on Kelham's part to have given us the whole of his life's work—and solid, pioneer work it has been—in a mere 188 pages.—F. G. St Clair STRANGE.

FRACTURE OF THE VERTEBRAL END-PLATE IN THE LUMBAR SPINE. An Experimental Biomechanical Investigation. By Olof PEREY. 9 × 6 in. Pp. 101, with 33 figures and 7 diagrams. 1957. Copenhagen: Ejnar Munksgaard. Acta Orthopaedica Scandinavica Supplementum No. XXV. Price Dan. kr. 25.00.

This is an account of work carried out to assess the effects of both static and dynamic stress applied through the long axis of the lumbar vertebrae and their intervening discs. The description of the experimental techniques employed and the discussion of the results are well arranged and clear, and the illustrations are excellent. The list of references is comprehensive.

The experimental work—In testing the effect of *dynamic* stress specimens of two lumbar vertebrae and their intervening discs were subjected to the impact of a vertically falling weight. The forces employed were accurately recorded. Repeated radiography (including discography with a radio-opaque and coloured fluid), visual checking and sectioning were used in assessing the results and also to reveal the state of the discs, whether normal or degenerate. Damage confined to the discs was unusual, but fractures occurred in twenty-six out of seventy-six experiments. Of these twenty-six fractures, six were compression fractures with some wedging of the bodies, the remainder being fractures of the end-plate only. These end-plate fractures were most often central depressions, sometimes marginal detachments of fragments, and occasionally transverse splits. With central depressions disc material was driven through into the spongiosa. Often these end-plate fractures could not be demonstrated by ordinary radiography. Tomography, or radiography of sagittal slices, were necessary to demonstrate many of them.

In a second series of experiments *static* strain was measured in a material testing apparatus at a constant rate of vertical load increased at a constant rate up to breaking point as indicated by a recording mechanism. Forty-five tests were made with two vertebrae and the intervening disc, and twenty-four with three vertebrae and two intervening discs. Here again fractures of the end-plate were common and were almost always of the central depression type. With most of these the discs showed no pre-existing degeneration. Like those following dynamic stress these end-plate fractures were seldom found by simple radiography, though demonstrable clearly by subsequent serial section. When it is remembered that these injuries were all in specimens stripped of their soft tissues, it is clear that they would have been still more unlikely to have been found by routine radiography had they occurred during life. Measurement of resistance to static stress of the isolated body showed a lowering of the level of breaking strain in specimens from individuals over the age of sixty, and that the lower lumbar bodies were rather stronger than the upper. Tests upon isolated end-plates showed that no one part of the plate's surface was measurably stronger than another, but there was considerable variation in the breaking strain between specimens from different individuals. The suggestion is made that central depression fractures of the plate are more likely to occur if the disc is normal so that pressure is transmitted through the disc as a whole, and that, with a degenerate disc, having less fluid in the nucleus, more pressure will be transmitted through the annulus and marginal fractures will be more likely.

The clinical application—Although not strictly comparable with the strains that may be exerted upon the spine during life these experiments suggest several interesting clinical possibilities. The frequent production, both by dynamic and by static stress, of end-plate fractures which cannot be detected by routine radiography suggests that such injuries may be far more common than has been realised. Examples are given of such end-plate fractures detected in patients by tomography. Discography would probably show such injuries equally well, but carries risks of its own. The subsequent sclerotic reaction around the disc material driven into the spongiosa with such end-plate fractures happening during life would presumably reveal them after a time to ordinary radiography as Schmorl's nodes. Some, though not all, such nodes are, therefore, probably caused by injury. It is known that heavy lifting strains can produce both crush fractures and marginal fractures of vertebral bodies. This work suggests that end-plate fractures, generally undetected by radiography, must even more frequently be caused by them. The tremendous static strain thrown upon the lower lumbar region in lifting with the spine flexed forward is emphasised, and the longer the individual's spine the greater it will be. Finally the dynamic stress thrown upon the spine of the pilot of a jet aircraft when using his ejection seat in an emergency is discussed at some length. The seat is fired out by explosive charges that must produce a violent acceleration if he is to be thrown clear of the aircraft tail. Spinal injuries from this are well known, and from discussion of the dynamics involved it is clear that stress is often very close to danger level.—R. W. BUTLER.

AN ATLAS OF MUSCLE PATHOLOGY IN NEUROMUSCULAR DISEASES. By J. Godwin GREENFIELD, M.D., G. Milton SHY, M.D., Ellsworth C. ALVORD, Jun., M.D., and Leonard BERG, M.D., from the Department of Health, Education and Welfare; Public Health Service; National Institutes of Health; National Institute of Neurological Diseases and Blindness; Bethesda, Maryland. Photomicrographs by Fred H. MEILLER. 10×7 in. Pp. ix+104, with many figures, some in colour, and 13 tables. Index. 1957. Edinburgh and London: E. & S. Livingstone Ltd. Price 45s.

One welcomes this book as a timely reminder both of our ignorance about many basic aspects of neuromuscular disease, and of the diagnostic difficulties that it presents. The etiology and pathogenesis of many of the syndromes concerned—including "Werdnig-Hoffmann's disease," "anterior compartment syndrome," "dermatomyositis," and even the various types of "muscular dystrophy" are not known, and there is consequently a certain vagueness in the clinical definition of these "entities." From the histological aspect too there is often a surprising degree of uncertainty about what different observers mean by such apparently precise terms as *necrosis*, *degeneration* and *inflammation* when these are applied to muscle. The present work does not pass over these difficulties, but its very attempt—and it is a most laudable one—to come to terms with them makes it a rather confusing introduction to the subject for the non-specialist reader. It is an illustrated account of a research project rather than a handy aid to practical diagnosis: it does not pretend to be a systematic account of the subject, but should help to set the stage for further advances in this difficult field. It should be read by all clinicians and pathologists who are interested in muscle disorders, and its conclusions should be in the minds of those—and their number is growing—who use biopsy as an aid to diagnosis in this field.

The authors, at the National Institute of Neurological Diseases and Blindness (Bethesda, Maryland, U.S.A.), approached the problem by carrying out a detailed investigation of 121 cases of muscular disease in which biopsy had been carried out. They tried to determine the fundamental histological reactions of muscle, and to establish any association between each of the various histological abnormalities and particular clinical conditions. Sections of the muscle biopsies, prepared by routine histopathological techniques, were examined by each of the authors without knowledge of the clinical details of the cases. The results were then discussed and the agreed opinion recorded. Only then was reference made to clinical observations and diagnostic impressions. The results of the investigation are presented in two parts. The first describes and illustrates what the authors have come to regard as the fundamental reactions of muscle to disease: the second evaluates the significance of each of these reactions as shown by their association with particular clinical observations.

The presence of large groups of abnormally small fibres, for instance, is recorded in some of the cases studied: it is identified as " neurogenic muscular atrophy " because of its association with disease of the lower motor neurone. Again, phagocytosis of muscle fibres and the presence of basophilic fibres with vesicular nuclei are often encountered together: it is found that they occur in a variety of clinical conditions, particularly those of an " inflammatory " or " degenerative " nature. Other abnormalities, including changes in fibre size, changes in interstitial tissues, leucocytic infiltrations, and abnormalities of peripheral muscular nerves, are recorded and analysed in the same fashion.

The authors conclude that in most neuromuscular diseases the clinical and histological observations, when objectively expressed, are complementary: in consequence biospy should be able to play a part in establishing or confirming diagnosis. Sometimes, however, uncertainty about the definition of the clinical syndromes and pathological processes concerned make it inevitable that clinical and histological findings appear to be in conflict: this would seem to be especially true in what the authors term the " proximal muscular syndromes " where there are inherent difficulties in distinguishing between " inflammatory " and " degenerative " disorders, *i.e.*, between various forms of " muscular dystrophy " and " myositis."

The book is well illustrated by numerous photomicrographs, many in colour.—H. A. Sissons.

THE PRINCIPLES AND ART OF PLASTIC SURGERY. By Sir Harold Gillies, *C.B.E.*, F.R.C.S.; and D. Ralph Millard, Jun., M.D., Diplomate, American Board of Plastic Surgery, Assistant Clinical Professor, University of Miami School of Medicine. Chapter on Anaesthesia by Ivan Magill, *C.V.O.*, F.F.A.R.C.S.; with a foreword by Jerome Pierce Webster, M.D., Professor of Clinical Surgery, College of Physicians and Surgeons, Columbia University. Volumes I and II. 11¼ × 9 in. Pp. xxviii + 652, with 2,472 figures, 122 in colour. Index. 1957. London: Butterworth & Co. (Publishers) Ltd. Price £12, 10s. per set.

This work has been awaited eagerly by the surgical world for, although its chief appeal is to the plastic surgeon, it will be read with very great interest by all who practise surgery. Here is a history of plastic surgery told in a compelling and vivid manner by the one most fitted to tell the story.

Harold Gillies, of Scottish descent, came from New Zealand to study medicine at Cambridge and Bart.'s. During the early days of the 1914–18 war Gillies's interest in plastic surgery was aroused and, in 1915, he founded a plastic unit at the Cambridge Hospital, Aldershot. It was not long before the value of his work was appreciated and a new hospital of 320 beds was built at Sidcup. Here it was that the foundations of this new speciality were laid, and to this hospital came his devoted assistants and associates from all the allied countries. Since those days plastic surgery has grown up through the years of peace and another world war. There is a great host of those afflicted by congenital defects, disease or injury who owe their recovery to Gillies and the men who at one time or another have worked with him.

This book follows an unusual course and contains many personal anecdotes and case histories, all of them fascinating and instructive. To those unfamiliar with the art of plastic surgery some of the results must appear almost miraculous. It is a work which is full of interest and indeed is difficult to lay down.

The orthopaedic surgeon—with justice called the general surgeon of to-day—should have some knowledge of plastic surgery. Much of the contents of this book is of no direct practical value to him but the chapters on free skin grafts and flaps, and in particular the section on trauma, will repay careful study.

Ralph Millard, the co-author, has done a grand job; the text is pleasant to read and the many excellent illustrations ride with the text. Butterworth & Co. are to be congratulated upon a fine achievement which is in keeping with the highest standards of medical publishing.—R. Guy Pulvertaft.

FRACTURES OF THE FACIAL SKELETON. By N. L. Rowe, F.D.S.R.C.S., L.R.C.P., M.R.C.S., H.D.D.R.C.S.; and H. C. Killey, F.D.S.R.C.S., L.R.C.P., M.R.C.S., H.D.D.R.C.S., Consultants in Oral Surgery, Plastic and Maxillo-facial Surgery Unit, Rooksdown House, Basingstoke. With a foreword by Sir Reginald Watson-Jones, and contributions from eight other authors. 10×7½ in. Pp. xxxvi+923, with 1,231 figures, 14 in full colour. Index. 1955. Edinburgh and London: E. & S. Livingstone Ltd. Price £6.

This is a book of reference on an essentially limited subject. The many excellent illustrations make the book vastly more interesting and instructive, but the cost might have been reduced by omitting some of the coloured illustrations where colour seems unnecessary and reproduction in black and white, and in larger size, would have offered advantages.

The book opens with a most informative review and analysis of 500 consecutive cases of facial bone fracture. After this come three main sections. The first two deal respectively with the mandible and the maxillae and associated parts; the third covers gunshot wounds and an assortment of other subjects, and for this the authors have enlisted the services of well known members of their team. Patrick Clarkson writes with the authority of an experienced campaigner on gunshot wounds of the face while F. A. Walker supports him on the dental side of the treatment of these alarming injuries. Particularly praiseworthy are the drawings illustrating the subsection " The preservation of life." Sir Harold Gillies contributes an excellent chapter on residual traumatic deformities, their diagnosis and treatment. G. E. Ennis and D. T. Gilchrist discuss in an admirably concise chapter of eight pages the anaesthetic difficulties peculiar to maxillo-facial injuries; C. R. McCash accepts responsibility for injuries of the scalp and the repair of skull defects; and W. G. Holdsworth deals with facial lacerations. This third section contains first-class chapters on ophthalmic injuries, associated intracranial injuries, radiography, post-operative care, the use of metals in fracture fixation, the healing of fractures, and the behaviour of bone grafts, and finally a gem of a chapter on historical background which makes delightful reading. There will be some difference of opinion about leaving dural tears (as indicated by leakage of cerebrospinal fluid) untreated when spontaneous arrest of the leak has occurred, but opinion on this important subject seems to be veering towards a " let well alone " policy although Lewin is quoted as assessing the risk of subsequent intracranial infection in such circumstances at 25 per cent.

The importance of team work, and of collaboration with the ophthalmic and neurological surgeons when injuries involve their spheres of action, is rightly stressed, and it is good to see full credit given to the all-important work of the anaesthetist.

The quotations at the beginning of the chapters are most apt and are an added delight which must have involved the authors in considerable literary research. In a book of this size which includes chapters contributed by several authors, there is always a danger of overlapping and redundancy, but the authors have avoided this. Clearly an enormous amount of work has been expended to make the book as perfect as possible.—T. Pomfret Kilner.

DIE HÜFTNAHEN FEMUROSTEOTOMIEN. Unter Berücksichtigung der Form, Funktion und Beanspruchung des Hüftgelenkes. By Maurice Edmond Müller. 11¼×8¼ in. Pp. xii+184, with 282 figures. Index. 1957. Stuttgart: Georg Thieme Verlag. Price DM 49.50.

This volume is beautifully produced in line with the other volumes of *Fortschritte auf dem Gebiete der Rontgenstrahlen und der Nuklearmedizin*, although it does not form one of the series. It presents with characteristic thoroughness the mechanical considerations governing osteotomies and the results of 297 osteotomies.

The volume is divided into two sections. The first section deals largely with the radiographic measurement of the angles of distortion of the femoral neck. This is comparatively straightforward in the antero-posterior views but more complicated in abnormal anteversion or retroversion. Dr Müller suggests that this angle is best measured with the hips flexed at right angles and the thighs abducted by 20 degrees. He has designed a simple appliance for maintaining the legs in this position. The measurement of the angle of distortion is facilitated by an " ischiometer." This is nothing more than a double protractor which can be placed on the top of the films. Translation of the measurement to the case at operation is made by means of a double protractor with scales at right angles to each other and each carrying a guide through which a Steinmann's pin is introduced into the femur above and below the osteotomy site. After osteotomy the pins are locked in position by special clamps and incorporated in the plaster. This method of control, without the ancillary instruments or with modified appliances, has been practised by many surgeons and is a valuable and accepted aid to osteotomy.

Proof of the value of the method described is well shown in the series of de-rotation osteotomies illustrated in the second section of the book, and these do the author great credit. If a volume designed to cover all osteotomies is not to become unwieldy there must necessarily be gaps in the consideration of special conditions, for instance, osteoarthritis of the hip, and of the correct osteotomy to choose. In describing slipped femoral epiphyses, open wedge resection is recommended for decreasing all retroversions of the head over 30 degrees. Many surgeons would tolerate angles up to 45 degrees, because of the risks of avascular necrosis inherent in open operation.

The volume bridges the gap between the radiologist, seeking to provide the most helpful films for the surgeon, and the surgeon seeking the best method of control and measurement of an osteotomy. The volume thus offers greater technical assistance than advice on the choice of this correct osteotomy in a particular case.—J G. BONNIN.

FLUID BALANCE IN SURGICAL PRACTICE. By L. P. Le QUESNE, D.M. (Oxon.), F.R.C.S. (Eng.), Assistant Director, Department of Surgical Studies, Middlesex Hospital. Second edition. $9 \times 5\frac{3}{4}$ in. Pp. vii+140, with 42 figures. Index. 1957. London: Lloyd-Luke (Medical Books) Ltd. Price 20s.

It is not surprising to find the appearance of a second edition of this monograph. Knowledge in this field has advanced sufficiently to require the revision of opinions and methods recorded three years ago. The layout and much of the material is the same in the second edition as in the first. More emphasis is placed on electrolyte balance, and attention paid to protein metabolism. There is a good but brief chapter on fluid balance in children, in relation to surgery; infants are included, and, although a great deal more could be said on the subject, much information is contained in a few pages.—J. C. SCOTT.

A SYNOPSIS OF SURGICAL ANATOMY. By A. Lee McGREGOR, M.Ch., F.R.C.S., Consulting Surgeon, Johannesburg General Hospital, Honorary Research Associate, University of the Witwatersrand. With a foreword by Sir Harold J. STILES, *K.B.E.*, F.R.C.S. (Edin.). Eighth edition. $7\frac{1}{2} \times 5\frac{1}{2}$ in. Pp. xii+808, with 766 figures. Index. 1957. Bristol: John Wright & Sons Ltd. Price 32s. 6d.

Lee McGregor's classic is suffering from the modern and fashionable disease of inflation. This edition has twenty-five pages more than the last edition, published in 1950. By reason of its weight it can no longer be recommended for reading in bed. Any orthopaedic surgeon could select paragraph after paragraph for deletion. For example, four pages are devoted to a précis of Putti's lecture on sciatica given at Liverpool thirty years ago; and in a synopsis of surgical anatomy even five lines is too much to devote to *snapping neck*.

Having written thus far, your reviewer in a captious mood continued to turn over the pages at random. When at last he recalled himself to his task two hours had passed. It is indeed a fascinating book.—George PERKINS.

BOOKS RECEIVED

These books are acknowledged with grateful thanks. Selections will be made for review as space permits and in accordance with their interest for our readers.

THE INFANTILE CEREBRAL PALSIES. By Eirene Collis, W. R. F. Collis, William Dunham, L. T. Hilliard and David Lawson. 1956. London: William Heinemann Medical Books Ltd.

ANKYLOSING SPONDYLITIS. By J. Forestier, M.D., F.A.C.R.(Hon.), F. Jacqueline, M.D., J. Rotes-Querol, M.D.; translated by A. U. Desjardins, M.S., M.D., F.A.C.P., F.A.C.R. 1956. Springfield, Illinois: Charles C. Thomas, Publisher. Oxford: Blackwell Scientific Publications. (Translation into English of *La Spondylarthrite Ankylosante*, reviewed by Philip Wiles—*Journal of Bone and Joint Surgery*, 1953, **35–B**, 165.

AN INTRODUCTION TO ELECTROMYOGRAPHY. By Fritz Buchthal, M.D. 1957. Copenhagen: Gyldendalske Boghandel.

SPINAL CORD COMPRESSION. By I. M. Tarlow, M.D. 1957. Springfield, Illinois: Charles C. Thomas, Publisher. Oxford: Blackwell Scientific Publications.

SIR GEORGE BUCKSTON BROWNE. By Jessie Dobson, B.A., M.Sc., and Sir Cecil Wakeley, Bt., *K.B.E., C.B.*, LL.D., D.Sc., F.R.C.S., F.R.A.C.S., F.A.C.S. 1957. Edinburgh and London: E. & S. Livingstone Ltd.

SYMPOSIUM OF TUBERCULOSIS. Edited by F. R. G. Heaf, M.A., M.D., F.R.C.P. 1957. London: Cassell & Company Limited.

DIE SPONDYLITIS TUBERCULOSA UND IHRE OPERATIVE BEHANDLUNG. By J. Kastert. Stuttgart: Hippokrates-Verlag.

ESSENTIALS OF MODERN SURGERY. Edited by R. M. Handfield-Jones, *M.C.*, M.S., F.R.C.S., and Sir Arthur Porritt, *K.C.M.G., C.B.E.*, M.A., M.Ch., F.R.C.S. Fifth edition. 1957. Edinburgh and London: E. & S. Livingstone Ltd.

THE GENESIS OF THE RAT SKELETON. By Donald G. Walker and Zolton T. Wirtschafter. 1957. Springfield, Illinois: Charles C. Thomas, Publisher. Oxford: Blackwell Scientific Publications.

PLASTER-OF-PARIS TECHNIQUE. By Marian English, S.R.N., R.F.N. 1957. Edinburgh and London: E. & S. Livingstone Ltd.

FRAKTUREN IM KINDESALTER. By Hans Rettig. 1957. Munchen: Verlag von J. F. Bergmann.

LEUKAEMIA AND APLASTIC ANAEMIA IN PATIENTS IRRADIATED FOR ANKYLOSING SPONDYLITIS. By W. M. Court-Brown, *O.B.E.*, M.B., B.Sc., F.F.R., and R. Doll, *O.B.E.*, M.D., F.R.C.P. 1957. London: Her Majesty's Stationery Office.

LEHRBUCH DER CHIRURGIE. By H. Hellner, R. Nissen and K. Vossschulte. 1957. Stuttgart: Georg Thieme Verlag.

ORTHOPEDIC SURGERY IN INFANCY AND CHILDHOOD. By Albert Barnett Ferguson, Jun., B.A., M.D., *et al.* 1957. London: Baillière, Tindall and Cox.

BERICHT ÜBER DIE BEI 3308 UNTERSCHENKELBRÜCHEN IN DEN JAHREN 1926–1950 IM WIENER UNFALLKRANKENHAUS ERZIELTEN BEHANDLUNGSERGEBNISSE UNTER BENÜTZUNG DES HOLLERITHVERFAHRENS. By Lorenz Böhler. 1957. Berlin, Gottingen, Heidelberg: Springer-Verlag.

DIE HEUTIGE BEHANDLUNG DER SKELETT-TUBERKULOSE DES KINDES UND DES JUGENDLICHEN. By Georg Glogowski. 1957. Stuttgart: Georg Thieme Verlag.

STUDIES IN SPONTANEOUS ATLAS DISLOCATION. By Sven Werne. 1957. Copenhagen: Ejnar Munksgaard. Acta Orthopaedica Scandinavica, Supplementum XXIII.

ARTHROPLASTY OF THE KNEE USING AN ENDOPROSTHESIS. By Börge Walldius. 1957. Copenhagen: Ejnar Munksgaard. Acta Orthopaedica Scandinavica, Supplementum XXIV.

DEGENERATIVE CHANGES IN THE STERNOCLAVICULAR AND ACROMIOCLAVICULAR JOINTS IN VARIOUS DECADES. By Anthony F. DePalma, M.D. 1957. Springfield, Illinois: Charles C. Thomas, Publisher. Oxford: Blackwell Scientific Publications.

OPERATIVE SURGERY. Under the General Editorship of Charles Rob, *M.C.*, M.Chir., F.R.C.S., and Rodney Smith, M.S., F.R.C.S. Vol. IV. 1957. London: Butterworth & Co. (Publishers) Ltd.

THE CLOSED TREATMENT OF COMMON FRACTURES. By John Charnley, B.Sc., M.B., F.R.C.S. Second edition. 1957. Edinburgh and London: E. & S. Livingstone Ltd.

MENSCHLICHE UND TIERISCHE GEWEBSTHROMBOKINASEN. By H. A. Thies. 1957. Stuttgart: George Thieme Verlag.

BIOENERGETICS. By Albert Szent-Gyorgyi. 1957. London: Academic Books Ltd.

PULMONARY COMPLICATIONS OF ABDOMINAL SURGERY. By A. R. Anscombe, M.S., F.R.C.S. 1957. London: Lloyd-Luke (Medical Books) Ltd.

FRACTURES AND RELATED INJURIES. By J. Grant Bonnin, M.B., B.S., F.R.C.S. 1957. London: William Heinemann Medical Books Ltd.

ACKNOWLEDGMENTS

We acknowledge with thanks receipt of:

Acta Chirurgica Scandinavica, and Supplements
Acta Ortopedica-Traumatologica Iberica
Annals of the Royal College of Surgeons of England
Archives of Surgery
Biological Abstracts
Boletin de la Sociedad de Cirugia del Uruguay
British Journal of Surgery
British Medical Bulletin
Canadian Journal of Surgery
Journal of Neurology, Neurosurgery and Psychiatry
Journal of the American Medical Association
Journal of the Royal College of Surgeons of Edinburgh
Lancet
Ortopedia e Traumatologia dell'Apparto Motore
Radiology
Revista de Ortopedia y Traumatologia
Revue de Chirurgie Orthopédique
Surgery, Gynecology and Obstetrics
Zeitschrift für Orthopädie und ihre Grenzgebiete

AUTHOR INDEX

A

Albert, M. Injuries to cervical spine (*discussion*), 794.
Allbrook, D. Movements of lumbar spine, 339.
Allen, C. Carpal tunnel syndrome (*discussion*), 794.
Allen, C. L.- *See* Lewer-Allen, C.
Alms, N. Tenosynovitis of flexor tendons of hand (*demonstration*), 157.
Anderson, J. Quadricepsplasty (*demonstration*), 597.
Anderson, M. Scoliosis (*demonstration*), 596.
Annan, J. H. Spontaneous atlanto-axial dislocation complicating spondylitis (*demonstration*), 582.
Anthonsen, W. Treatment of congenital club foot, 599.
Apley, A. G. Surgical treatment of tardy ulnar neuritis (*discussion*), 782.
Arden, G. P. Variations in joint space of hip as shown radiographically, 750.
Armstrong, G. W. Hip fusion after failed prosthesis, 799.
Ashurst, G. M. *See* Howat, T. W., and Ashurst, G. M.
Aston, J. N. An adaptor for extracting McLaughlin nails, 755.
Etiology of idiopathic pes cavus, 585.
Auckland, G., Ball, J., and Griffiths, D. Ll. Ainhum, 513.

B

Bachynski, B. A familial arrested variant of Friedrich's ataxia, 792.
Fractures of humerus (*discussion*), 792.
Bailey, R. W. Calcinosis circumscripta, 584.
Baker, G. W. Treatment of Perthes' disease, 594.
Ball, J. *See* Auckland, G., Ball, J., and Griffiths, D. Ll.
Barbier, J. M. *See* Guilleminet, M., and Barbier, J. M.
Barry, H. Complications of internal fixation of fractures of tibia, 595.
Congenital absence of radius and thumb (*discussion*), 596.
Grice's operation for pes valgus, 596.
Orthopaedic surgery in modern China, 800.
Osteosarcoma (*discussion*), 597.
Bartelink, D. L. The role of abdominal pressure in relieving the pressure on the lumbar intervertebral discs, 718.
Bedbrook, G. M., and Doyle, W. A. Prosthesis for tetraplegics, 132.
Bell, G. H. Mechanical properties of bone, 780.
Benjamin, A. Relief of traumatic arterial spasm in threatened Volkmann's ischaemic contracture, 711.
Berry, T. A. Morton's metatarsalgia due to cavernous angioma, 124.
Bertelsen, A. Treatment of congenital club foot, 599.
Eskesen, B., and Remvig, O. Treatment and rehabilitation of patients with paraplegia from spinal cord injuries and diseases, 600.
Beswick, I. P. *See* Jacobs, J. H., Hess, E. V., and Beswick, I. P.
Biggers, J. D. Studies on cultivation of embryonic chick bones in chemically defined media, 591.
Bingold, A. C. Osteochondritis dissecans (*demonstration*), 156.
and France, W. G. Bone tumours treated by excision and internal prosthesis (*demonstration*), 156.
Bintcliffe, E. W. Bilateral congenital deformities of hand and forearm (*demonstration*), 788.
Traumatic arterial spasm (*demonstration*), 788.
and Marcroft, J. T. Juvenile hallux valgus (*demonstration*), 787.
Blandy, J. P., and Fuller, R. March gangrene, 679.
Blockey, N. J. *See* Charnley, J., Blockey, N. J., and Purser, D. W.
Bonney, G. L. W. *See* Kessel, A. L., and Bonney, G. L. W.
Bonnin, J. G. *Book reviews*, 607, 806.
Boonzaier, A. C. Orthopaedic tuberculosis (*discussion*), 160.
Botterell, E. H. *Book review*, 166.
Boucher, H. H. Recurrent anterior dislocation of shoulder (*discussion*), 795.
Bourdillon, J. Some aspects of referred pain, 790.
Brennan, J. Neoplasm in thigh (*demonstration*), 594.
Bridges, J. B., and Pritchard, J. J. Bone and cartilage induction in rabbit, rat and guinea-pig, 591.
Brook, A. L. E.- *See* Eyre-Brook, A. L.
Brookes, M. Femoral growth after occlusion of principal nutrient canal in day-old rabbits, 563.
Brooks, D. M. Short leg in poliomyelitis (*discussion*), 781.
Brown, T. S.- *See* Stubbs-Brown, T.
Bryan, J. Cervical dislocation (*discussion*), 596.
Bryson, A. Delayed primary closure following sequestrectomy in chronic osteomyelitis, 779.
Buck, J. E. Bilateral osteochondritis dissecans of knee (*demonstration*), 592.
Charnley compression for ununited tibial fracture (*demonstration*), 593.
Posterior [dorsal] interosseous nerve palsy (*demonstration*), 593.
Gap suture of extensor pollicis longus tendon (*demonstration*), 593.
Spastic flat foot (*demonstration*), 593.
Buraczewski, J., Lysakowska, J., and Rudowski, W. Chondroblastoma (Codman's tumour) of thoracic spine, 705.
Burger, M. *See* Lavine, L. S., Burger, M., and Sobel, A. E.
Burns, B. H. The first operation for torn cartilage of knee joint, 791.
Burns, S. Tetanus, 787.
Burrows, H. J. *Book Review*, 604.
Freiberg's infraction (*discussion*) 580.
Slipped upper femoral epiphysis, 641.
Burton, A. E. Sclerosing osteomyelitis, 790.
Burton, W. Observations at opening ceremony of clinical meeting in Oswestry at Robert Jones Centenary Meeting, 588.
Butler, R. W. *Book Review*, 803.
Unusual conditions in femur (*demonstration*), 423.
Buxton, St J. D. Personal appreciation of Robert Jones, 203.

C

Callow, F. Adamantinoma (*discussion*), 596.
Carbuncle of hip (*discussion*), 597.
Early bone grafting of fractures (*discussion*), 595.
Fracture-dislocation of hip (*discussion*), 596.
Operations on painful feet (*discussion*), 596.
Osteosarcoma (*discussion*), 597.
Quadricepsplasty (*discussion*), 597.
Shoulder pain (*discussion*), 595.

Cameron, J. A. P. Bone changes in haemophilia (*discussion*), 794.
Juxta-epiphysial metaphysitis in infancy (*discussion*), 793.
See Karlen, A. G., and Cameron, J. A. P.
Capener, N. *Book review*, 604.
Personal appreciation of Robert Jones, 208.
Referred pain (*discussion*), 790.
Treatment of pertrochanteric fractures (*editorial*),436.
Caravias, D. E. Forward dislocation of elbow without fracture of olecranon, 334.
Some observations on congenital dislocation of head of radius, 86.
Carter, C. Genetics in orthopaedics, 778.
Catterall, R. C. F. Charnley compression for ununited tibial fracture (*discussion*), 593.
Caughey, J. E., Gwynne, J. F., and Jefferson, N. R. Dystrophia myotonica associated with familial Paget's disease with sarcomata, 316.
Chalmers, J. Tissue immunity factors in bone homografting, 581.
Charnley, J. Cancellous strip bone grafting (*discussion*), 585.
Blockey, N. J., and Purser, D. W. Treatment of displaced fractures of neck of femur by compression, 45.
Charters, A. D. Local gigantism, 542.
Cheetham, R. W. S. Durban mystery outbreak (*discussion*), 161.
Cholmeley, J. A. Chronic synovitis of knee (*discussion*), 592.
Chowdhury, S. Experimental intra-articular fractures, 164.
Clarke, H. O.- *See* Osmond-Clarke, H.
Cloke, J. Early bone grafting of fractures, 595.
Scoliosis (*discussion*), 596.
Shoulder pain (*discussion*), 595.
Cohen, B. K.- *See* Keon-Cohen, B.
Cohen, Lord. Personal appreciation of Robert Jones, 191.
Coleman, H. M. Recurrent instability of ankle (*discussion*), 795.
and Murray, J. F. Acrocephalosyndactylism, 792.
Collins, D. H. Histological structure of bone, 779.
Colquhoun, J. Congenital dislocation of hip (*discussion*), 596.
Contracture of tensor fasciae latae in old poliomyelitis (*discussion*), 595.
Cysts of femur (*demonstrations*), 597.
Eosinophilic granuloma of femoral shaft (*demonstration*), 598.
Fractured neck of talus (*discussion*), 597.
Perthes' disease (*discussion*), 597.
Sequelae of burns (*discussion*), 597.
Coltart, W. D. Short leg in poliomyelitis (*discussion*), 781.
Colvin, G. *Demonstrations*, 597.
Perthes' disease (*discussion*), 597.
Shoulder pain (*discussion*), 595.
Commerell, J. J. Orthopaedic tuberculosis, 161.
Treatment of flat foot in children (*discussion*), 160.
Conlon, P. C. *See* Hanley, T., and Conlon, P. C.
Cooksey, F. S. *See* Langdale-Kelham, R., and Cooksey, F. S.
Cooper, J. Mechanics of disc physiology (*discussion*), 797.
Cox, L. A. *See* Simmons, E. H., and Cox, L. A.
Cram, R. H. Acrocephalosyndactylism (*discussion*), 792.
Crawford, A. Leg equalisation (*demonstration*), 597.
Crawford, H. Contracture of tensor fasciae latae in old poliomyelitis (*discussion*), 595.
Early bone grafting of fractures (*discussion*), 595.
Grice's operation (*discussion*), 596.
Operations on painful feet (*discussion*), 596.
Shoulder pain (*discussion*), 595.
Creer, W. S.- *See* Sayle-Creer, W.
Crowe, H. E. Bone cysts (*discussion*), 791.
Curtiss, P. Tissue immunity factors in bone homografting (*discussion*), 581.

D

Davenport, C. *Book review*, 433.
Davidson, I. W. Recurrent instability of ankle (*discussion*), 795.
Davies, H. Intramedullary nailing, 788.
Traumatic osteoma of femur (*demonstration*), 788.
Traumatic removal of major part of internal condyle of femur and tibia (*demonstration*), 789.
Dawson, K. B. Calcium exchange *in vivo*, 421.
Denham, R. A. Theoretical analysis of hip mechanics, 783.
and Law, W. A. Arthroplasty of hip, 614.
Dent, C. E., Harper, C. M., and Philpot, G. R. Insensitivity to calciferol developing during treatment of various forms of metabolic rickets and osteomalacia, 422.
Devas, M. B. Creeping keloid (*demonstration*), 788.
Stress fracture of tibia in athletes, 783.
Stress fractures (*demonstration*), 787.
See also Dickson, J. W., and Devas, M. B.
Dewar, F. P. Improvement of hand function in tetraplegics, 791.
Injuries to cervical spine (*discussion*), 795.
Plaster-of-Paris bandages (*discussion*), 794.
and Hall, J. E. Recurrent dislocation of patella, 798.
Dick, G. W. A. Live virus vaccination, 584.
Dickson, J. W., and Devas, M. B. Bankart's operation for recurrent dislocation of shoulder, 114.
Donaldson, J. R. Reconstruction of hand in leprosy, 163.
Doyle, W. A. *See* Bedbrook, G. M., and Doyle, W. A.
Durbin, F. C. Conservative treatment of slipped epiphysis (*discussion*), 789.
Fracture-dislocation of cervical spine, 23.
Duthie, H. L. Radial nerve in osseous tunnel at humeral fracture site diagnosed radiographically, 746.
Dwyer, F. C. Adolescent hallux rigidus (*discussion*), 582.
Osteotomy of calcaneum in treatment of pes cavus, 163.

E

Edelstein, J. M. Cause of congenital deformities of feet (*discussion*), 163.
Osteochondritis dissecans (*discussion*), 159.
Elliott, G. B., and Townsend, R. G. Adamantinoma, 791.
English, R. Durban mystery outbreak (*discussion*), 162.
Eskesen, B. *See* Bertelsen, A., Eskesen, B., and Remvig, O.
Evans, D. Management of fractures into knee (*discussion*), 789.
Treatment of cavo-varus foot and club foot, 789.
Evans, D. L. Recurrent instability of ankle, 795.
Visit of the 1956 Travelling Fellows to United States and Canada, 580.
and Lloyd-Roberts, G. C. Treatment of Perthes' disease, 782.
Evans, E. M. Adolescent hallux rigidus (*discussion*), 582.
Amputation in relation to severe compound fractures of tibia (*discussion*), 158.
Book review, 601.

Eyre-Brook, A. L. Congenital deformities (*demonstration*), 157.
Conservative treatment of slipped epiphysis (*discussion*), 789.
Late results of arthroplasty of elbow (*demonstration*), 157.
Traumatic osteoma of femur (*discussion*), 789.
Treatment of club foot of cavo-varus type (*discussion*), 790.

F

Fahrni, W. H. Mechanics of disc physiology as related to early stages of disc degeneration from the clinical aspect, 796.
Fairbank, Sir H. A. T. Personal appreciation of Robert Jones, 198.
Fairbank, T. J. *Book review*, 607.
Congenital anomalies (*demonstration*), 422.
Favreau, J. C. Leg lengthening operation, 797.
and LaBelle, P. Hallux valgus and hallux rigidus, 792.
Fessler, H. Load distribution in a model of a hip joint, 145.
Fielding, J. W. Cineradiography of normal cervical spine (*film*), 585.
Findlay, M. Malignant bone tumours, 162.
Fitton-Jackson, S. Electron microscopy of bone, 780.
Fitzgibbon, G. M. Amputation in relation to severe compound fracture of tibia (*discussion*), 158.
Flatt, A. E. Thenar flap, 80.
Fouché, F. P. Treatment of flat feet in children (*discussion*), 160.
Fowler, A. W. Flexion-compression injury of sternum, 487.
Surgery of fixed claw toes, 585.
Surgery of the nail, 790.
France, W. G. Central dislocation operation for osteoarthritis of hip (*demonstration*), 156.
Chronic synovitis of knee (*discussion*), 592.
Congenital dislocation of hip (*demonstration*), 156.
Pectoral transplant, 156.
See also Bingold, A. C., and France, W. G.
Freiberg, J. A. Bone cysts (*discussion*), 791.
Frenette, U. Hallux valgus and hallux rigidus (*discussion*), 793.
Fuller, R. *See* Blandy, J. P., and Fuller, R.

G

Gallagher, M. Bone cyst (*demonstration*), 597.
Fractured neck of talus (*discussion*), 597.
Operations on painful feet (*discussion*), 596.
Gallie, E. Personal appreciation of Robert Jones, 193.
Gardner, A. M. N., and Harrison, M. H. M. Report of treatment of experimental fat embolism with heparin, 538.
Gariepy, R. Use of Henry's hinge graft, 799.
Gayton, W. Fracture-dislocation of hip (*demonstration*), 596.
Osteochondromatosis of elbow (*demonstration*), 598.
Gissane, W. Usual anatomy of posterior dislocation of shoulder, 579.
Gleave, J. R. W. *See* Taylor, R. G., and Gleave, J. R. W.
Godfrey, L. W. Arthrodesis of ankle and subtalar joint (*demonstration*), 422.
Dislocation of hip with fracture of head of femur, 423.
Golding, J. S. R. Carpal tunnel syndrome (*discussion*), 794.
Goldthwait, J. E. Personal appreciation of Robert Jones, 192.
Gordon, G. C. Genetics in orthopaedics (*discussion*), 779.
Griffiths, D. Ll. *Book reviews*, 168, 174, 176, 433, 604, 608.
The maintenance of traumatic arterial spasm (*editorial*), 613.
See also Auckland, G., Ball, J., and Griffiths, D. Ll.
Guilleminet, M., and Barbier, J. M. Osteochondritis dissecans of hip, 268.
Gunn, D. R., and Molesworth, B. D. Use of tibialis posterior as a dorsiflexor, 674.
Gwynne, J. F. *See* Caughey, J. E., Gwynne, J. F., and Jefferson, N. R.

H

Hall, J. E. Results of treatment of slipped femoral epiphysis, 659.
See also Dewar, F. P., and Hall, J. E.
Hall, R. McK. Carbuncle of hip (*discussion*), 597.
Osteomyelitis (*demonstration*), 597.
Hall, W. H. Muscle power and development (*demonstration*), 790.
Hamada, G. Unreduced anterior dislocation of hip, 471.
Hamilton, A. Cervical dislocation (*discussion*), 596.
Congenital dislocation of hip (*discussion*), 596.
Hamilton, A. R. Congenital absence of radius and thumb (*discussion*), 596.
Contracture of tensor fasciae latae in old poliomyelitis (*discussion*), 596.
Coxa valga (*discussion*), 597.
Fibrous dysplasia, 597.
Fibrous dysplasia of hip (*demonstration*), 597.
Leg equalisation (*discussion*), 597.
Osteosarcoma (*discussion*), 597.
Painful feet (*discussion*), 596.
Perthes' disease (*discussion*), 597.
Radiographic bone changes in cretin (*demonstration*), 598.
Hanley, T., and Conlon, P. C. Congenital deformity of carpus associated with maldevelopment of certain thenar muscles, 458.
Harding, H. E., and Langdale-Kelham, R. Amputation stumps, 221.
Harper, C. M. *See* Dent, C. E., Harper, C. M., and Philpot, G. R.
Harris, C. H. Field studies in vaccination against poliomyelitis, 583.
Harris, R. I. Accelerated consolidation of fractures (*discussion*), 796.
Juxta-epiphysial metaphysitis in infancy (*discussion*), 793.
Harrison, M. H. M. *See* Gardner, A. M. N., and Harrison, M. H. M.
Harrold, A. J. Charles Bell Keetley (1848–1909), 572.
Hazlett, J. W. Pyogenic osteomyelitis of spine, 798.
Hedden, F. J. Management of scoliosis, 162.
Helfet, A. J. Treatment of flat feet in children, 160.
Hellinga, G. Effect of hormones on skeletal growth, 164.
Henry, L. Treatment of club foot of cavo-varus type (*discussion*), 790.
Hess, E. V. *See* Jacobs, J. H., Hess, E. V., and Beswick, I. P.
Hill, R. C. J. Durban mystery outbreak resembling Icelandic disease, 161.
Treatment of flat foot in children (*discussion*), 160.
Hirsch, C. Clinical assessment of low back pain and sciatica, 798.

Hodgkinson, R. Contracture of tensor fasciae latae in old poliomyelitis, 595.
Fractured neck of talus (*demonstration*), 597.
Osteogenic sarcoma of femur, 597.
Perthes' disease (*discussion*), 597.
Shoulder pain (*discussion*), 595.
Hollenberg, C. Intervertebral disc physiology (*discussion*), 797.
Recurrent anterior dislocation of shoulder (*discussion*), 795.
Holloway, P. J. *See* Mellanby, Lady M., and Holloway, P. J.
Horn, J. S. Ancient and modern orthopaedics in China, 779.
Houghton, H. G. Orthopaedic tuberculosis, 161.
Howat, T. W., and Ashurst, G. M. Pseudohypoparathyroidism, 39.
Hudson, C. Relief of sciatica (*demonstration*), 598.
Hughes, J. R. Congenital vertical talus, 580.
Internal fixation in displacement osteotomy of upper end of femur (*discussion*), 782.
Value of bone biopsy to surgeon, 421.
Hughes, S. Experimental embryology of tooth germs, 591.
Hume, A. C. Anterior dislocation of head of radius associated with undisplaced fracture of olecranon in children, 508.

J

Jackson, D., and Weidmann, S. M. Relationship between age and fluorine content of human bones and teeth, 422.
Jackson, S. F.- *See* Fitton-Jackson, S.
Jackson, O. J. V.- *See* Vaughan-Jackson, O. J.
Jacobs, J. H., Hess, E. V., and Beswick, I. P. Rheumatoid arthritis presenting as tenosynovitis, 288.
James, E. S. Cavernous angiomata in muscles of extremities, 799.
Subtotal removal of scapula for aneurysmal bone cyst, 128.
James, J. I. P. *Book review*, 432.
Charnley compression for ununited fracture of tibia (*discussion*), 593.
Leg shortening (*discussion*), 592.
Short leg in poliomyelitis (*discussion*), 781.
Jansen, K. Treatment of congenital club foot, 599.
Jarry, L., and Uhthoff, H. K. Experimental study of accelerated consolidation of fractures, 795.
" Petals " versus bony transplants in treatment of experimental pseudarthrosis, 799.
Jefferson, N. R. *See* Caughey, J. E., Gwynne, J. F., and Jefferson, N. R.
Jeffery, C. C. Case of pollicisation of index finger, 120.
Fracture-dislocation of hip with displacement of bone fragment into acetabulum during closed reduction, 310.
Non-union of epiphysis of lateral condyle of humerus, 582.
Jenkins, S. A. Operation for osteoarthritis of hip (*discussion*), 156.
Jensen, J. S.- *See* Saugmann-Jensen, J.
Johnston, D. C. Fractures of humerus (*discussion*), 792.
Johnston, J. L. Compensable low back disabilities, 798.
Jones, D. M. Congenital absence of radius (*demonstration*), 157.
Congenital varus deformity of tibia (*demonstration*), 157.
Pain of cervical origin, 157.
Jones, G. B. Conservative treatment of slipped epiphysis (*discussion*), 789.
Early diagnosis and treatment of congenital dislocation of hip (*film*), 158.
Jones, M. V. Oligodactyly, 752.
Jones, Lady P. Speech at dinner of Robert Jones Centenary Meeting, 586.
Jørgensen, A. Spasticity during sleep in children with cerebral palsy, 599.
Joubert, P. Durban mystery outbreak (*discussion*), 162.
Judet, R. Hip prostheses, 799.

K

Kamp, J. H. J. van der. Scapulo-thoracic arthrodesis for Erb's disease, 164.
Kaplan, C. J. Recurrent sprains of ankle (*discussion*), 159.
Orthopaedic tuberculosis, 161.
Karlen, A. G., and Cameron, J. A. P. Dysplasia epiphysialis punctata, 293.
Kelham, R. L.- *See* Langdale-Kelham, R.
Kendall, J. D. Perthes' disease of hip, 790.
Kennedy, J. C. Management of fractures through middle third of humerus, 792.
McFarlane, R. M., and McLachlin, A. D. The Moe plate in intertrochanteric fractures of femur, 451.
Keon-Cohen, B. Adamantinoma (*discussion*), 596.
Complications of internal fixation of tibial fractures (*discussion*), 595.
Coxa valga (*discussion*), 597.
Operations on painful feet, 596.
Osteosarcoma (*discussion*), 597.
Quadricepsplasty (*discussion*), 597.
Tumour of medial condyle of femur (*demonstration*), 598.
Kerridge, J. Painful feet (*discussion*), 596.
Kessel, A. W. L. Internal fixation in displacement osteotomy of upper end of femur (*discussion*), 782.
and Bonney, G. L. W. Adolescent hallux rigidus, 581.
Kilner, T. P. *Book review*, 806.
King, T. Complications of internal fixation of fractures of tibia (*discussion*), 595.
Congenital absence of radius and thumb (*discussion*), 596.
Coxa valga (*discussion*), 597.
Fractured neck of talus (*discussion*), 597.
See also Morgan, F. P., and King, T.
Kristoffersen, K. Treatment of slipped femoral epiphysis, 599.
Kyle, J. Use of cortisone and hydrocortisone, 594.

L

LaBelle, P. *See* Favreau, J. C., and LaBelle, P.
Lahz, J. Adamantinoma of mandible (*demonstration*), 596.
Bilateral coxa valga, with slipped epiphysis (*demonstration*), 597.
Complications of internal fixation of tibial fractures (*discussion*), 595.
Congenital absence of radius and thumb (*discussion*), 596.
Shoulder pain (*discussion*), 595.
Lancaster, R. P.- *See* Percy-Lancaster, R.
Landells, J. W. Reactions of injured human articular cartilage, 548.

Langdale-Kelham, R., and Cooksey, F. S. Preparation of the amputee and stump for limb fitting, 224.
See also Harding, H. E., and Langdale-Kelham, R.
Langham, J. Influence of thyroid hormone on embryonic development, 164.
Langton, C. Shoulder pain from local causes, 594.
Laperriere, V. Osteogenic sarcoma (*demonstration*), 797.
Larochelle, J. L. Synovial sarcoma (*demonstration*), 797.
Laurence, W. Charnley compression for ununited tibial fracture (*discussion*), 593.
Laurin, C. A. *See* Mustard, W. T., and Laurin, C. A.
Lavine, L. S., Burger, M., and Sobel, A. E. Effect of bone bank preservation on calcifying mechanism, 758.
Law, W. A. *See* Denham, R. A., and Law, W. A.
Leclerc, J. Multiple congenital deformities, 797.
Lécutier, M. A., and Smith, A. H. Air embolism as complication of medullary nailing, 534.
Lehmann, E. C. H. Familial osteodystrophy of skull and face, 313.
LeMesurier, A. B. Juxta-epiphysial metaphysitis in infancy (*discussion*), 793.
Lemieux, J. Multiple myeloma (*demonstration*), 797.
Lemoine, A. Vascular changes after interference with blood flow of femoral head of rabbit, 763.
Lepine, E. Hindquarter amputation (*demonstration*), 797.
Lessard, J. M. Paget's disease of bone, 797.
LeVay, A. D. Chronic synovitis of knee (*demonstration*), 592.
Excision of old tuberculous hip and leg shortening operation (*demonstration*), 592.
Osteitis pubis after inguinal herniorrhaphy (*demonstration*), 592.
Levitt, W. M. *Book review*, 606.
Lewer-Allen, C. Recurrent sprains of ankle (*discussion*), 159.
Lindsey, E. A. Chronic synovitis of knee (*discussion*), 592.
Little, G. A. Surgical approach to sacro-iliac joint, 783.
Lloyd-Roberts, G. C. *See* Evans, D. L., and Lloyd-Roberts, G. C.
Lofthouse, R. N. Bone changes in haemophilia, 794.
Visit of American and Canadian Travelling Fellows to Great Britain, 784.
Lucas, K. Amputation in relation to severe compound fractures of tibia (*discussion*), 158.
Complete tetraplegia, 157.
Lysakowska, J. *See* Buraczewski, J., Lysakowska, J., and Rudowski, W.

M

McBride, E. Hallux valgus and hallux rigidus (*discussion*), 793.
McConkey, A. S. Recurrent anterior dislocation of shoulder (*discussion*), 795.
McCormack, M. P. Arthrodesis of hip (*demonstration*), 157.
McDonald, J. L. Juxta-epiphysial metaphysitis in infancy (*discussion*), 793.
MacDonald, W. Congenital dislocation of hip (*discussion*), 596.
Fibrous dysplasia, 597.
Fractured neck of talus (*discussion*), 597.
Perthes' disease (*discussion*), 597.
Sequelae of burns (*demonstration*), 597.
McDougall, A., and White, J. Subluxation of inferior radio-ulnar joint complicating fracture of radial head, 278.
McFadden, D. G. Method of repairing chronic dislocation of acromio-clavicular joint, 799.
McFarland, B. Congenital vertical talus (*discussion*), 580.
Non-union of epiphysis of lateral condyle of humerus (*discussion*), 582.
Personal appreciation of Robert Jones, 199.
Tribute to Robert Jones and Vittorio Putti, 424.
McFarlane, R. M. *See* Kennedy, J. C., McFarlane, R. M., and McLachlin, A. D.
MacIntosh, D. L. Spontaneous fracture of femoral neck after deep x-ray treatment, 799.
McIntyre, J. M. Spondylolisthesis in children, 797.
McKee, G. K. Arthrodesis of the hip with a lag-screw, 477.
McKenzie, D. S. Prosthetic management of congenital deformities of extremities, 233.
MacKinnon, W. B. Pott's disease in children, 798.
Recurrent anterior dislocation of shoulder joint, 795.
McLachlin, A. D. *See* Kennedy, J. C., McFarlane, R. M., and McLachlin, A. D.
McMurray, F. Speech at dinner of Robert Jones Centenary Meeting, 586.
McMurray, T. B. Recurrent sprains of ankle (*discussion*), 159.
Macnab, I. Blood supply of tibia, 799.
McPhee, I. Osteomyelitis (*demonstration*), 597.
McSweeney, A. Congenital dislocation of hip (*demonstration*), 596.
Osteogenesis imperfecta (*demonstration*), 598.
Supracondylar osteotomy for knock-knee (*demonstration*), 598.
Malkin, S. A. S. Personal appreciation of Robert Jones, 203.
Malvern, Viscount. Personal appreciation of Robert Jones, 190.
Marcroft, J. T. Charnley compression for ununited tibial fracture (*discussion*), 593.
Comminuted fracture of scaphoid bone (*demonstration*), 788.
Osteoid osteoma of tibia (*demonstration*), 787.
Traumatic arterial spasm (*demonstration*), 788.
See also Bintcliffe, E. W., and Marcroft, J. T.
Martin, D. J. Senile peripheral vascular failure, 594.
Martin, N. Spinal fusion in tuberculosis, 594.
Maxwell, M. Congenital dislocation of hip (*discussion*), 596.
Mayer, L. Personal appreciation of Robert Jones, 196.
Mehta, M. T. Experimental diaphysectomy, 164.
Mellanby, Lady M., and Holloway, P. J. Tissue culture as tool in dental research, 591.
Menzies, J. Personal appreciation of Robert Jones, 210.
Mercer, Sir W. *Book reviews*, 426, 429.
Orthopaedic tuberculosis, 160.
Osteochondritis dissecans (*discussion*), 159.
Merle d'Aubigné, R. Diaphyso-epiphysial resection for bone tumours of knee, 779.
Meyer, P. C. Histological and microradiographic study of osteogenesis imperfecta, 786.
Milsom, H. B. C., and Rose, B. S. Arthritis of hip complicating osteitis pubis, 701.
Mishra, N. K. *See* Mukopadhaya, B., and Mishra, N. K.
Molesworth, B. D. *See* Gunn, D. R., and Molesworth, B. D.
Moller, C. T. Treatment of flat foot in children (*discussion*), 160.
Moloney, J. Fracture-dislocation of hip (*discussion*), 596.
Morgan, F. P., and King, T. Primary instability of lumbar vertebrae as common cause of low back pain, 6.
Morgan, N. Painful feet (*discussion*), 596.
Shoulder pain (*discussion*), 595.

Morissette, G. Milkman's syndrome, 797.
Mortens, J. Charnley's central dislocation operation for osteoarthritis of hip, 598.
Movin, R. Compression arthrodesis of hip, 599.
Requirements for hip prosthesis in replacement arthroplasty, 598.
Müller, G. M. Simple prosthesis for rural amputees, 131.
Mukherji, A. K. Recurrent dislocation of shoulder, 164.
Mukopadhaya, B., and Mishra, N. K. Treatment of tuberculous sinuses and abscesses of osteo-articular origin, 326.
Mulder, J. D. Progress in orthopaedic surgery in Holland, 164.
Mullins, J. F. P. Recurrent sprains of ankle, 159.
Murdoch, G. Errors of diagnosis revealed at meniscectomy, 502.
Murray, D. S. Fatigue fractures of lower tibia and fibula in same leg, 302.
Murray, J. F. *See* Coleman, H. M., and Murray, J. F.
Murray, R. O. *Book review*, 606.
Radiological aspects of osteogenesis imperfecta, 786.
Mustard, W. T., and Laurin, C. A. Fusions about talus in children, 798.

N

Nicholson, O. R. Longitudinal osteotomy of tibia, 738.
Nissen, K. I. Surgical treatment of tardy ulnar neuritis (*discussion*), 782.
Northcroft, G. B. Diastematomyelia (*demonstration*), 593.
Partial paraplegia due to bone tumour (*demonstration*), 593.
Nuffield, Lord. Letter to Editor, 610.

O

O'Connell, J. E. A. *Book review*, 176.
Ortolani, M. Early diagnosis and treatment of congenital dislocation of hip (*film*), 158.
Osborne, G. V. Surgical treatment of tardy ulnar neuritis, 782.
Osmond-Clarke, H. Amputations (*editorial*), 218.
Congenital vertical talus (*discussion*), 580.
Idiopathic knock-knee (*discussion*), 581.
Owen, R. Fibrocystic lesions of bone (*request for material*), 802.

P

Page, Sir M. Personal appreciation of Robert Jones, 201.
Parker, D. Carbuncle of hip (*discussion*), 597.
Congenital dislocation of hip (*discussion*), 596.
Contracture of tensor fasciae latae in old poliomyelitis (*discussion*), 595.
Early bone grafting of fractures (*discussion*), 595.
Gunshot wound of forearm (*demonstration*), 597.
Malignant tumour of humerus (*demonstration*), 597.
Scoliosis (*discussion*), 596.
Shoulder pain (*discussion*), 595.
Parkes, A. R. Surgical treatment of tardy ulnar neuritis (*discussion*), 782.
Paterson, I. The torn acetabular labrum, 306.
Patterson, F. P. Recurrent instability of ankle (*discussion*), 795.
Pennal, G. F. Central dislocation of hip joint, 800.
Percy-Lancaster, R. Durban mystery outbreak (*discussion*), 162.
Osteochondritis dissecans, 159.
Perkins, G. *Book reviews*, 433, 807.
Personal appreciation of Robert Jones, 202.
Perry, W. L. M. Preparation and testing of poliomyelitis vaccine, 583.
Philpot, G. R. *See* Dent, C. E., Harper, C. M., and Philpot, G. R.
Pimm, L. H., and Waugh, W. Tuberculous tenosynovitis, 91.
Platt, Sir H. Hallux valgus, 787.
Plewes, L. W. *Book review*, 428.
Polonsky, B. Osteochondritis dissecans (*discussion*), 159.
Potter, C. M. C. Sweat gland tumour of hand, 102.
Preston, F. Bone cysts, 791.
Price, C. H. G. Primary osteogenic tumours of skeleton, 157.
Price, E. Cervical dislocation (*discussion*), 596.
Congenital absence of radius and thumb (*discussion*), 596.
Congenital dislocation of hip (*discussion*), 596.
Fracture-dislocation of hip (*discussion*), 596.
Grice's operation (*discussion*), 596.
Leg equalisation (*discussion*), 597.
Perthes' disease (*discussion*), 597.
Scoliosis (*discussion*), 596.
Shoulder pain, 594.
Price, G. H. G., and Truscott, D. E. Multifocal osteogenic sarcoma, 524.
Price, T. Calcaneo-cavus deformity of foot treated by two-stage procedure, 789.
Conservative treatment of slipped epiphysis (*demonstration*), 789.
Pridie, K. H. Cartilage grafts in osteochondritis dissecans of knee (*demonstration*), 157.
Management of fractures into knee (*discussion*), 789.
Osteosclerosis of tibia (*demonstration*), 157.
Sclerosing osteomyelitis (*discussion*), 790.
Stainless steel fixation for arthrodesis (*demonstration*), 157.
Treatment of club foot of cavo-varus type (*discussion*), 790.
Pritchard, A. E. Epiphysial stapling in idiopathic knock-knee, 581.
Pritchard, Sir F. E. Personal appreciation of Robert Jones, 197.
Pritchard, J. J. Research in osteology, 594.
See also Bridges, J. B., and Pritchard, J. J.
Pulvertaft, R. G. *Book reviews*, 174, 805.
Purser, D. W., and Sharp, J. Spontaneous atlanto-axial dislocation, a complication of spondylitis, 582.
See also Charnley, J., Blockey, N. J., and Purser, D. W.
Pyper, J. B. Excision of coccyx, 594, 733.

Q

Quinlan, A. G. Hallux valgus and hallux rigidus (*discussion*), 793.

R

Ratliff, A. H. C. The short leg in poliomyelitis, 781.
Recht, W. Remodelling of lower radial epiphysis after fracture separation (*demonstration*), 790.
Remvig, O. *See* Bertelsen, A., Eskesen, B., and Remvig, O.
Richard, D. R. Slipped femoral epiphysis, 158.
Richards, H. J. Traumatic osteoma of femur (*discussion*), 788.

Richardson, T. A. Bone cysts (*discussion*), 791.
Ritchie, T. *Book review*, 172.
Roaf, R. Cancellous strip bone grafting (*discussion*), 585.
Foramen in humerus caused by median nerve, 748.
Idiopathic knock-knee (*discussion*), 581.
Normal and abnormal movements of spine with special reference to scoliosis, 579.
Roberts, G. C. Ll.- *See* Lloyd-Roberts, G. C.
Roberts, N. Juxta-epiphysial metaphysitis in infancy (*discussion*), 793.
Osteochondritis dissecans (*editorial*), 219.
Robertson, D. E. Fracture-dislocation of lumbar spine, 742.
Robinson, R. Shoulder pain (*discussion*), 595.
Robson, P. N., and Tibbs, D. J. Aneurysm complicating traumatic spondylolisthesis, 498.
Roger, J. P. Unilateral intracranial protrusion of condyle of mandible, 797.
Rose, B. S. *See* Milsom, H. B. C., and Rose, B. S.
Ross, J. P. *Book review*, 170.
Rostrup, O. Recurrent instability of ankle (*discussion*), 795.
Roulston, T. J. Familial arrested variant of Friedreich's ataxia (*discussion*), 792.
Rowe, D. Early bone grafting of fractures (*discussion*), 595.
Roy, L.-P. Blount's disease, 797.
Bone changes in haemophilia (*discussion*), 794.
Royle, H. Fracture-dislocation of hip (*demonstration*), 596.
Rudowski, W. *See* Buraczewski, J., Lysakowska, J., and Rudowski, W.
Rushton, M. A. Dentinogenesis imperfecta, 786.

S

Samson, J. E. Surgical treatment of chronic arthritis of hip, 799.
Saugmann-Jensen, J. Buschenfeldt's corset in treatment of scoliosis, 599.
Sayani, I. H. Osteomyelitis of tibia, 423.
Unusual cases of fracture of fibula in women (*demonstration*), 422.
Sayle-Creer, W. Congenital vertical talus (*discussion*), 580.
Idiopathic knock-knee (*discussion*), 581.
Scaglietti, O. Tribute to Robert Jones and Vittorio Putti, 423.
Scott, J. C. *Book review*, 807.
Movements of spine with reference to scoliosis (*discussion*), 579.
See also Somerville, E. W., and Scott, J. C.
Scott, J. H. Mechanical basis of bone formation, 134.
Scougall, S. Posterior dislocation of shoulder, 726.
Seddon, H. J. *Book reviews*, 432, 602.
Calcinosis circumscripta (*discussion*), 585.
Delayed primary closure following sequestrectomy in chronic osteomyelitis (*discussion*), 779.
Surgical treatment of tardy ulnar neuritis (*discussion*), 782.
Segal, A. Restoration of elbow flexion after paralysis, 781.
Sen, S. S. Effect of epiphysiodesis on muscle tissue, 164.
Malunited Colles's fracture, 164.
Sewell, R. H. Charnley compression for ununited tibial fracture (*discussion*), 593.
Sharp, J. *See* Purser, D. W., and Sharp, J.
Sharrard, W. J. *Book review*, 431.
Fractures of humerus (*discussion*), 792.
Shephard, E. Posterior [dorsal] interosseous nerve palsy (*discussion*), 593.
Simmons, E. H., and Cox, L. A. Clinical and experimental study of plaster-of-Paris bandages, 793.
Sissons, H. A. *Book reviews*, 169, 804.
Microradiography of bone, 780.
Sladden, R. A. Intravascular osteoclasts, 346.
Smillie, I. S. Freiberg's infraction, 580.
Treatment of osteochondritis dissecans, 248.
Smith, A. H. *See* Lécutier, M. A., and Smith, A. H.
Smith, W. H. Fractured neck of talus (*discussion*), 597.
Fracture-dislocation of hip (*discussion*), 596.
Painful feet (discussion), 596.
Sobel, A. E. *See* Lavine, L. S., Burger, M., and Sobel, A. E.
Somerville, E. W. Persistent foetal alignment of hip, 106.
and Scott, J. C. The direct approach to congenital dislocation of hip, 623.
Spira, E. Replacement of biceps brachii by pectoralis minor transplant, 126.
Spring, E. Adamantinoma (*discussion*), 596.
Cervical dislocation (*demonstration*), 596.
Congenital absence of radius and thumb (*discussion*), 596.
Shoulder pain (*discussion*), 595.
Traumatic atlanto-axial dislocation (*demonstration*), 596.
Starr, D. E. Fracture-dislocation of body of talus, 799.
Juxta-epiphysial metaphysitis in infancy, 793.
Stener, B. Dislocation of the shoulder complicated by complete rupture of axillary artery, 714.
Stephen, R. Coxa valga (*discussion*), 597.
Stewart, S. F. Dysplasia of tendons of feet as cause of congenital deformities, 162.
Stirling, R. I. Adolescent hallux rigidus (*discussion*), 581.
Book review, 170.
Stonham, F. Arthrographs of knees and shoulder (*demonstration*), 598.
Complications of internal fixation of tibial fractures (*discussion*), 595.
Scoliosis (*discussion*), 596.
Strange, F. G. St C. *Book review*, 803.
Excision of old tuberculous hip (*discussion*), 592.
Stringa, G. Studies of vascularisation of bone grafts, 395.
Stubbs-Brown, T. Carbuncle of hip, 597.
Sturrock, D. Complications of internal fixation of tibial fractures (*discussion*), 595.
Early bone grafting of fractures (*discussion*), 595.
Quadricepsplasty (*discussion*), 597.
Swinburne, K. Diabetic neuropathy (*demonstration*), 422.

T

Taylor, G. W. *Book review*, 171.
Taylor, R. G., and Gleave, J. R. W. Incomplete spinal cord injuries, 438.
Teece, L. Avulsion fracture of calcaneum (*demonstration*), 598.
Early bone grafting of fractures (*discussion*), 595.
Osteomyelitis (*demonstration*), 597.
Painful feet (*discussion*), 596.
Secondary neoplasm of femur (*demonstration*), 598.
Shoulder pain (*discussion*), 595.
Tennant, D. C. Epiphysial injuries (*demonstration*), 593.
Thomas, F. B. Reduction of Smith's fracture, 463.
Thomas, G. E. Personal appreciation of Robert Jones, 211.
Thompson, N. M. Orthopaedic tuberculosis, 160.
Thompson, W. Carpal tunnel syndrome (*discussion*), 794.
Thompson, W. J. Hand function in tetraplegics (*discussion*), 791.
Injuries to cervical spine, 794.

Tibbs, D. J. *See* Robson, P. N., and Tibbs, D. J.
Townsend, R. G. *See* Elliott, G. B., and Townsend, R. G.
Trevor, D. Bilateral osteochondritis of knee (*demonstration*), 592.
Chronic synovitis of knee (*discussion*), 592.
Treatment of congenital dislocation of hip (*editorial*), 611.
Trottier, A. E. Fractures of humerus (*discussion*), 792.
Juxta-epiphysial metaphysitis in infancy (*discussion*), 793.
Trueta, J. Appraisal of vascular factors in the healing of fractures of the femoral neck (*editorial*), 3.
Book reviews, 167, 171, 430, 603.
Normal vascular anatomy of human femoral head during growth, 358.
Personal appreciation of Robert Jones, 208.
Truscott, D. E. *See* Price, G. H. G., and Truscott, D. E.
Tuck. W. H. Drop-foot appliance with concealed spring, 335.
Tucker, F. R. Gritti-Stokes amputation, 798.
Tupman, G. S. Management of fractures into knee joint, 789.

U

Uhthoff, H. K. *See* Jarry, L., and Uhthoff. H. K.

V

Vaughan, J. M. Radioactive isotopes and bone, 780.
Vaughan-Jackson, O. J. Operation for osteoarthritis of hip (*discussion*), 156.

W

Walker, D. *See* Ward, F. G., and Walker, D.
Ward, F. G., and Walker D. *Demonstrations*, 787.
Wardle, E. N. Internal fixation in displacement osteotomy of upper end of femur, 782.
Watson, D. Congenital absence of radius and thumb (*demonstration*), 596.
Watson-Jones, Sir R. Anatomy of posterior dislocation of shoulder (*discussion*), 580.
Edward Gallie, 436.
Honours to orthopaedic surgeons, 784.
Idiopathic knock-knee (*discussion*), 581.
Lord Nuffield (*editorial*), 609.
Osteochondritis of thoracic spine, sacroiliitis condensans and ankylosing spondylitis, 582.
Personal appreciation of Robert Jones, 180.
Robert Jones 1857-1933 (*editorial*), 179.
Waugh, W. Partial cubo-navicular coalition as cause of peroneal spastic flat foot, 520.
See also Pimm, L. H., and Waugh, W.
Weidmann, S. M. *See* Jackson, D., and Weidmann, S. M.
Welply, W. R. Carpal tunnel syndrome, 794.
West, E. Contracture of tensor fasciae latae in old poliomyelitis (*discussion*), 595.
Coxa valga (*discussion*), 597.
Fracture-dislocation of hip (*discussion*), 596.
Grice's operation (*discussion*), 596.
Leg equalisation (*discussion*), 597.
Painful feet (*discussion*), 596.
Shoulder pain, 595.
Weston, W. J. Metaphysial fractures in infancy, 694.
Wherrett, R. Congenital dislocation of hip (*discussion*), 596.
Cyst of femur (*demonstration*), 597.
Gonadal protection against x-rays (*demonstration*), 598.
White, J. Osteochondritis dissecans in association with dwarfism, 261.
See McDougall, A., and White, J.
Wiles, P. *Book reviews*, 429.
Speech at dinner of Robert Jones Centenary Meeting, 587.
Wilkinson, M. C. Partial synovectomy and curettage in treatment of tuberculosis of hip, 66.
Williamson, J. C. F. Ll. Osteitis pubis after inguinal herniorrhaphy (*discussion*), 592.
Wilson, C. L. Central dislocation of hip joint, 800.
Wilson, J. N. Cancellous strip bone grafting, 585.
Non-union of epiphysis of lateral condyle of humerus (*discussion*), 582.
Simple traction harness for cervical manipulation, 756.
Wilson, N. Coxa valga (*discussion*), 597.
Perthes' disease (*demonstration*), 597.
Wilson, P. D. An American appreciation of Robert Jones, 194.
Wilson, R. I. Intramedullary nailing of femoral fractures (*demonstration*), 594.
Winchester, I. W. Results of spinal fusion for scoliosis, 579.
Withers, R. J. Rupture of musculo-tendinous cuff, 594.
Wood, H. L.-C. Charnley compression for ununited tibial fracture (*discussion*), 593.
Posterior interosseous nerve palsy (*discussion*), 593.
Wright, A. M. Sterilisation of homogenous bone grafts by beta proprio lactone, 798.

Z

Zanoli, R. Krukenberg-Putti amputation-plasty, 230.

SUBJECT INDEX

A

Abdominal pressure, role of, in relieving pressure on lumbar intervertebral discs, 718.
Acetabular labrum, torn: block to reduction of dislocated hip, 306.
Acrocephalosyndactylism, 792.
Acromio-clavicular joint, dislocation, chronic, method of repairing, 799.
Adamantinoma, 791.
  of mandible (*demonstration*), 596.
Ainhum, 513.
Amputation, Gritti-Stokes, 798.
  in relation to severe compound fractures of tibia (*discussion*), 158.
  preparation of amputee and stump for limb fitting, 224.
  stumps, 221.
Amputation-plasty, Krukenberg-Putti, 231.
Amputations (*editorial*), 218.
Amputees, rural, simple prosthesis for, 131.
Angiomata, cavernous, in muscles of extremities, 799.
  Morton's metatarsalgia due to, 124.
Ankle and subtalar joint, arthrodesis of (*demonstration*), 422.
  instability of, recurrent, surgical treatment, 795.
  osteochondritis dissecans, 159.
  sprains of, recurrent, 159.
Anomalies, congenital (*demonstration*), 422.
Arterial spasm, traumatic (*demonstrations*), 788.
    maintenance of (*editorial*), 613.
    relief of, in threatened Volkmann's ischaemic contracture, 711.
Arthritis, rheumatoid, presenting as tenosynovitis, 288.
Arthrodesis, stainless steel fixation for (*demonstration*), 157.
Association of Surgeons of India, meeting, Sept. 1956, 163.
Atlanto-axial dislocation, spontaneous, complicating spondylitis, 582.
  traumatic (*demonstration*), 596.
Australian Orthopaedic Association, Annual General Meeting, 1956, 594.
Axillary artery, complete rupture of, complicating dislocation of shoulder; successful suture of artery, 714.

B

Back, low, disabilities, compensable, 798.
  pain, clinical assessment of, 798.
    primary instability of lumbar vertebrae as common cause of, 6.
Bandages, plaster-of-Paris, clinical and experimental study of, 793.
Bankart's operation for recurrent dislocation of shoulder, 114.
Belgian Orthopaedic Society, new category of foreign associate member, 424.
Beta proprio lactone in sterilisation of homogenous bone grafts, 798.
Biceps brachii, replacement of, by pectoralis minor transplant, 126, 156.
Bone and Tooth Society meeting, June 1956, 421.
    Oct. 1956, 591.
    symposium on osteogenesis imperfecta and dentinogenesis imperfecta, 786.
  bank, preservation, effect of, on calcifying mechanism, 758.
Bone biopsy, value to surgeon, 421.
  changes in haemophilia, 794.
  cysts, 791; (*demonstration*), 597.
  electron microscopy of, 780.
  fibrocystic lesions of (*request for material*), 802.
  formation, mechanical basis of, 134.
  grafting, cancellous strip, 585.
    homogenous, tissue immunity factors in, 581.
    of fractures, early, 595.
  grafts, homogenous, sterilisation of, by beta proprio lactone, 798.
    vascularisation of, 395.
  histological structure of, 779.
  induction in rabbit, rat and guinea-pig, 591.
  mechanical properties of, 780.
  microradiography of, 780.
  radioactive isotopes and, 780.
  symposium on, 779.
  tuberculous abscesses and sinuses, treatment of, 326.
  tumours, malignant, diagnosis and treatment of, 162.
    partial paraplegia due to (*demonstration*), 593.
    primary osteogenic, 157.
    treated by excision and internal prosthesis (*demonstration*), 156.
Bones, embryonic chick, cultivation of, in chemically defined media, 591.
Book reviews:
  Adams, J. C. Outline of fractures, 1957, 428.
  Aird, I. A companion in surgical studies, 2nd edition, 1957, 433.
  Böhler, L. The treatment of fractures, Vol. 1, 1956, 176; Vol. 2, 1957, 608.
  Bourne, G. H., *ed.* The biochemistry and physiology of bone, 1956, 167.
  Brash, J. C. Neuro-vascular hila of limb muscles, 1955, 170.
  Brugsch, H. G. Rheumatic diseases, rheumatism and arthritis, 1957, 604.
  Bunnell, S. Surgery of the hand, 3rd edition, 1956, 174.
  Ciba Foundation. Bone structure and metabolism, 1956, 168.
  Clark, K. C. Positioning in radiography, 7th edition, 1956, 605.
  Clark, M., *ed.* Lectures on orthopaedics and the rheumatic diseases, 1956, 429.
  Crowe, F. W., Schill, W. J., and Neel, J. V. Clinical, pathological and genetic study of multiple neurofibromatosis, 1956, 174.
  Dodd, H., and Cockett, F. B. The pathology and surgery of the veins of the lower limb, 1956, 171.
  Evans, F. G. Stress and strain in bones, 1957, 603.
  Forni, I., and Cappellini, O. Compendio di meccanica articolare, 1956, 603.
  Furlong, R. Injuries of hand, 1957, 601.
  Gillies, Sir H., and Millard, D. R., jun. The principles and art of plastic surgery, 1957, 805.
  Goidanich, I. F. Tumori dello scheletro, 1956, 429.
  Graham, E. C., and Mullen, M. M. Rehabilitation literature, 1950–1955, 1956, 433.
  Greenfield, J. G., *et al.* An atlas of muscle pathology in neuromuscular diseases, 1957, 804.
  Hulth, A. Intra-osseous venographies of medial fractures of femoral neck, 1956, 430.
  Kelham, R. D. L. Artificial limbs in the rehabilitation of the disabled, 1957, 803.
  Kerr, D., and Brunnstrom, S. Training of the lower extremity amputee, 1956, 172.
  Kerr, W. G. Surgery, 1957, 604.

Book reviews (*continued*):
Key, J. A., and Conwell, H. E. The management of fractures, 6th edition, 1956, 432.
LeQuesne, L. P. Fluid balance in surgical practice, 1957, 807.
McGregor, A. L. A synopsis of surgical anatomy, 1957, 807.
Martin, P., *et al.* Peripheral vascular disorders, 1956, 170.
Merle d'Aubigné, R., Bénassy, J., and Ramadier, J.-O. Chirurgie orthopédique des paralysies, 1956, 602.
Müller, M. F. Die hüftnahen Femurosteotomien, 1957, 806.
Nathan, Lord. Medical negligence, 1957, 606.
Pap, K. Die Diafixation, 1956, 607.
Perey, O. Fracture of the vertebral end-plate in the lumbar spine, 1957, 803.
Pietrogrande, V. I tumori metastatici dello scheletro, 1956, 429.
Rob, C., and Smith, R., *eds.* Operative surgery, 3 vols., 1957, 426.
Rowe, N. L., and Killey, H. C. Fractures of the facial skeleton, 1955, 806.
Russell, W. R. Poliomyelitis, 2nd edition, 1956, 432.
Schmorl, G., and Junghanns, H. Die gesunde und die kranke Wirbelsäule in Röntgenbild und Klinik, 4th edition, 1956, 607.
Seddon, H. J., *ed.* Peripheral nerve injuries, 1954, 166.
Spurling, R. G. Lesions of the cervical intervertebral disc, 1956, 176.
Stein, I., Stein, R. O., and Beller, M. L. Living bone, 1955, 169.
Tompsett, D. H. Anatomical techniques, 1956, 171.
Trueta, J., Wilson, A. B. K., and Agerholm, M. Handbook on poliomyelitis, 1956, 431.
Waller, A. Dorsal acetabular fractures of the hip, 1955, 433.
Williams, D., *ed.* Modern trends in neurology, 1957, 604.
British Orthopaedic Association, autumn meeting, 1957, 778.
election of officers, etc., 783.
Robert Jones Centenary Meeting, 579.
Brown-Séquard phenomena, incomplete spinal cord injuries with, 438.
Burns, sequelae of (*demonstration*), 597.
Buschenfeldt's corset in treatment of scoliosis, 599.

C

Calcaneum, avulsion fracture of (*demonstration*), 598.
osteotomy of, in treatment of pes cavus, 163.
Calciferol, insensitivity to, developing during treatment of various forms of metabolic rickets and osteomalacia, 422.
Calcifying mechanism, effect of bone bank preservation on, 758.
Calcinosis circumscripta: local and metabolic study, 584.
Calcium exchange *in vivo*, 421.
Canadian Journal of Surgery, 800.
Orthopaedic Association, annual meeting, 1956, 791.
1957, 797.
officers elected June 1956, 163.
Carpal tunnel syndrome, 794.
Carpus, congenital deformity of, associated with maldevelopment of certain thenar muscles, 458.
fusion of greater multangular and navicular bones of, (*demonstration*), 157.
Cartilage induction in rabbit, rat and guinea-pig, 591.
injured articular, reactions of, 548.
Charnley's central dislocation operation for osteoarthritis of hip, 598.
compression for ununited tibial fracture (*demonstration*), 593.
China, modern orthopaedic surgery in, 800.
orthopaedics in, ancient and modern, 779.
Chondroblastoma of thoracic spine, 705.
Club foot, congenital, treatment of, 599.
of cavo-varus type, treatment of, 789.
Coccydynia, excision of coccyx for, 594, 733.
Coccyx, excision of, for coccydynia, 594, 733.
Codman's tumour of thoracic spine, 705.
Colles's fracture, malunited, 164.
reversed, reduction of, 463.
Cortisone, use in orthopaedic conditions, 594.
Coxa valga, bilateral, with slipped epiphysis (*demonstration*), 597.
Cretin, bone changes in (*demonstration*), 598.
Cubo-navicular coalition, partial, as cause of peroneal spastic flat foot, 520.

D

Danish Orthopaedic Association meeting, Oct. 1955, 598.
spring 1956, 598.
Nov. 1956, 600.
Denmark, orthopaedic activities in, 598.
Dentinogenesis imperfecta, symposium on, 786.
Diabetic neuropathy treated by Lisfranc's amputation (*demonstration*), 422.
Diaphysectomy, experimental, 164.
Diaphyso-epiphysial resection for bone tumours of knee, 779.
Diastematomyelia (*demonstration*), 593.
Disc, intervertebral, cervical lesions, pain due to, 157.
physiology, mechanics of, as related to early stages of degeneration, 796.
Discs, intervertebral, lumbar, role of abdominal pressure in relieving pressure on, 718.
Dorsal interosseous nerve palsy (*demonstration*), 593.
Drop-foot appliance with concealed spring, 335.
Durban mystery outbreak resembling Icelandic disease, 161.
Dwarfism, osteochondritis dissecans in association with, 261.
Dysplasia epiphysialis punctata, 293.
fibrous, 597.
Dystrophia myotonica associated with familial Paget's disease with sarcomata, 316.

E

East Anglian Orthopaedic Club meeting, Dec. 1956, 422.
March 1957, 593.
Elbow, anterior dislocation of head of radius associated with undisplaced fracture of olecranon in children, 508.
arthroplasty of, late results (*demonstration*), 157.
congenital dislocation of head of radius, 86.
dislocation of, forward, without fracture of olecranon, 334.
flexion, restoration of, after paralysis, 781.
osteochondritis dissecans of, 159.
osteochondromatosis of (*demonstration*), 598.
paralysis, restoration of flexion after, 781.
Embolism, air, as complication of medullary nailing, 534.
fat, experimental, treatment with heparin, 538.
Epiphysial injuries (*demonstration*), 593.
Epiphysiodesis, effect on muscle tissue, 164.
Erb's disease, scapulo-thoracic arthrodesis for, 164.
Extensor pollicis longus tendon, gap suture of (*demonstration*), 593.
Extremities, congenital deformities of, prosthetic management of, 233.

F

Face and skull, familial osteodystrophy of, 313.
Femur and tibia, traumatic removal of major part of internal condyle of (*demonstration*), 789.
avascular necrosis of capital epiphysis (*demonstration*), 597.
" cystic " changes in (*demonstration*), 423.
cysts of (*demonstration*), 597.
displacement osteotomy of upper end of, internal fixation in, 782.
eosinophilic granuloma of shaft of (*demonstration*), 598.
epiphysis, slipped, 158.
treatment of, 599.
conservative (*demonstration*), 789.
upper, 641.
results of treatment, 659.
fracture, intramedullary nailing of (*demonstration*), 594.
of head of, in dislocation of hip, 423.
neck of, appraisal of vascular factors in healing of (*editorial*), 3.
displaced, treatment by compression, 45.
spontaneous, after deep x-ray therapy, 799.
shaft of, intramedullary nailing of, 788.
pertrochanteric, treatment of (*editorial*), 436.
with Moe plate, 451.
growth of, after occlusion of principal nutrient canal in day-old rabbits, 563.
osteogenic sarcoma of, 597.
osteoma of, traumatic (*demonstration*), 788.
secondary neoplasia of (*demonstration*), 598.
tumour of medial condyle (*demonstration*), 598.
vascular anatomy of head of, during growth, 358.
changes after interference with blood flow in head of, in rabbit, 763.
Fibula, fracture of, fatigue, and of tibia in same leg, 302.
unusual cases (*demonstration*), 422.
Finger, index, pollicisation of, 120.
injured, thenar flap for, 80.
Fluorine content of bones and teeth, relationship to age, 422.
Foot, calcaneo-cavus deformity of, treated by two-stage procedure, 789.
club, congenital, treatment of, 599.
of cavo-varus type, treatment of, 789.
congenital deformities of, dysplasia of tendons as cause of, 162.
vertical talus, 580.
drop-, appliance with concealed spring, 335.
flat, in children, treatment of, 160.
spastic (*demonstration*), 593.
hallux rigidus, adolescent, 581.
arthrodesis for, 792.
valgus, 787.
arthrodesis for, 792.
juvenile (*demonstration*), 787.
painful, operations on, 596.
peroneal spastic flat, partial cubo-navicular coalition as cause of, 520.
pes cavus, osteotomy of calcaneum in treatment of, 163.
valgus, Grice's operation for, 596.
tendons of, dysplasia of, as cause of congenital deformities, 162.
Foot-piece, simple, for rural amputees, 131.
Forearm and hand, bilateral congenital deformities of (*demonstration*), 788.
gunshot wound of, treatment of (*demonstration*), 597.
Fractures, accelerated consolidation of, experimental study of, 795.
early bone grafting of, 595.
intra-articular, experimental, 164.
Fractures, metaphysial, in infancy, 694.
stress (*demonstration*), 787.
Freiberg's infraction, 580.
Friedreich's ataxia, familial arrested variant of, 792.

G

Gallie, Edward (*portrait*), 435.
seventy-fifth birthday, 435.
Gangrene, march, 679.
Genetics in orthopaedics, 778.
German Democratic Republic, Orthopaedic Association of, 1957 meeting, 600.
Gibson, Alexander (*obituary*), 154.
Gigantism, local, 542.
Gonadal protection against x-rays (*demonstration*), 598.
Grice's operation for pes valgus, 596.
Gritti-Stokes amputation, 798.

H

Haemophilia, bone changes in, 794.
Hallux rigidus, adolescent, 581.
arthrodesis for, 792.
valgus, 787.
arthrodesis for, 792.
juvenile (*demonstration*), 787.
Hand and forearm, bilateral congenital deformities of (*demonstration*), 788.
flexor tendons of, tenosynovitis of (*demonstration*), 157.
function in tetraplegics, improvement of, 791.
reconstruction of, in leprosy, 163.
sweat gland tumour of, 102.
Henry's hinge graft, use of, 799.
Heparin, treatment of experimental fat emoblism with, 538.
Herniorrhaphy, inguinal, osteitis pubis after (*demonstration*), 592.
Hip, arthritis, chronic, surgical treatment of, 799.
complicating osteitis pubis, 701.
arthrodesis (*demonstration*), 157.
compression, 599.
with a lag-screw, 477.
arthroplasty, 614.
carbuncle of, 597.
coxa valga, bilateral, with slipped epiphysis (*demonstration*), 597.
dislocation, anterior, unreduced, 471.
central, 800.
congenital (*demonstration*), 156, 596.
direct approach to, 623.
early diagnosis and treatment of (*film*), 158.
treatment of (*editorial*), 611.
torn acetabular labrum as block to, 306.
with fracture of head of femur, 423.
fibrous dysplasia of (*demonstration*), 597.
foetal alignment of, persistent, 106.
fracture-dislocation (*demonstration*), 596.
with displacement of bone fragment into acetabulum during closed reduction, 310.
fusion after failed prosthesis, 799.
load distribution in a model of, 145.
mechanics, theoretical analysis of, 783.
osteoarthritis, central-dislocation operation for (*demonstration*), 156.
Charnley's central dislocation operation for, 598.
McMurray osteotomy for, tetanus following, 787.
osteochondritis dissecans, 268.
Perthes' disease, 790.

Hip prosthesis, 799.
failed, fusion after, 799.
in replacement arthroplasty, requirements for, 598.
slipped femoral epiphysis, 158, 641.
conservative treatment of (*demonstration*), 789.
results of treatment, 659.
tuberculosis, central-dislocation-arthrodesis for, 160.
diagnosis and treatment, 160.
excision of head and neck of femur in, 160.
partial synovectomy and curettage in treatment of, 66.
tuberculous, old, excision of, and leg shortening operation (*demonstration*), 592.
variation in joint space of, as shown radiographically, 750.
Holland, progress in orthopaedic surgery in, 164.
Hormones, effect on skeletal growth, 164.
Humerus, foramen in, caused by median nerve, 748.
fracture, radial nerve in osseous tunnel at site of, diagnosed radiographically, 746.
through middle third of, management of, 792.
malignant tumour of (*demonstration*), 597.
non-union of epiphysis of lateral condyle of, 582.
Hunt, Agnes (*portrait*), 184.
Hydrocortisone, use in orthopaedic conditions, 594.

I

Icelandic disease, Durban mystery outbreak resembling, 161.
India, Association of Surgeons of, meeting, Sept. 1956, 163.
Intervertebral disc lesions, cervical, pain due to, 157.
lumbar, role of abdominal pressure in relieving pressure on, 718.
physiology, mechanics of, as related to early stages of degeneration, 796.
Irish Orthopaedic Club, meeting, Nov. 1956, 159.
April 1957, 594.
Irwin, S., knighted, 784.
Ischaemic contracture, Volkmann's, threatened, relief of traumatic arterial spasm in, 711.
Isotopes, radioactive, and bone, 780.
Italian Orthopaedic Association, annual meeting, Oct. 1956, 165.

J

Joints, tuberculous sinuses and abscesses, treatment of, 326.
Jones, Sir Robert (1857-1933) (*editorial*), 179.
and Vittorio Putti, tributes to, 423.
biographies of, 217.
Centenary Meeting, British Orthopaedic Association, 579.
Service in Liverpool Cathedral, 590.
Volume, 179.
chronological list of contributions to surgical literature, 212.
Dining Club dinner at Liverpool, 590.
Golf Competition, 1957, 590.
personal appreciations of, 180-211.
portraits, 180, 185, 188.

K

Keetley, Charles Bell (1848-1909), 572.
Keloid, creeping (*demonstration*), 788.
Knee, bone tumours of, diaphyso-epiphysial resection for, 779.
chronic synovitis of (*demonstration*), 592.
dislocation of patella, recurrent, 797.
errors of diagnosis revealed at meniscectomy, 502.
fractures into, management of, 789.
knock-, idiopathic epiphysial stapling in, 581.
supracondylar osteotomy for (*demonstration*), 598.
osteochondritis dissecans of (*demonstration*), 156.
bilateral (*demonstration*), 592.
cartilage grafts in (*demonstration*), 157.
torn cartilage of, first operation for, 791.
traumatic removal of major part of internal condyle of femur and tibia (*demonstration*), 789.
Köhler's second disease, 580.
Krukenberg-Putti amputation-plasty, 230.

L

Leg lengthening operation, 797.
muscles, ischaemic myositis of, from exercise, 679.
shortening (*demonstration*), 597.
operation (*demonstrations*), 592.
Leprosy, reconstruction of hand in, 163.
use of tibialis posterior as a dorsiflexor in, 674.
Lisfranc's amputation in treatment of diabetic neuropathy (*demonstration*), 422.
Liverpool University, award of M.Ch.(Orth.) degrees, 1956, 156.

M

McLaughlin nails, adaptor for extracting, 755.
Mandible, adamantinoma of (*demonstration*), 596.
unilateral intracranial protrusion of condyle of, 797.
March gangrene, 679.
Median nerve, foramen in humerus caused by, 748.
Meniscectomy, errors of diagnosis revealed at, 502.
Metaphysial fractures in infancy, 694.
Metaphysitis, juxta-epiphysial, in infancy, 793.
Metatarsalgia, Morton's, due to cavernous angioma, 124.
Moe plate in intertrochanteric fractures of femur, 451.
Morris, Selwyn B. (1906-1956) (*obituary*), 578.
Morton's metatarsalgia due to cavernous angioma, 124.
Muscle power and development (*demonstration*), 790.
tissue, effect of epiphysiodesis on, 164.
Musculo-tendinous cuff, rupture of, 594.

N

Nail, surgery of, 790.
Nailing, medullary, air embolism as complication of, 534.
Nails, McLaughlin, adaptor for extracting, 755.
North-West Metropolitan Orthopaedic Club, meeting, Dec. 1956, 422.
May 1957, 786.
Nuffield, Lord (*editorial*), 609.
portrait, facing 609.
Orthopaedic Centre, Oxford, lectures, 156.

O

Obituaries:
Gibson, Alexander, 154.
Morris, S. B., 578.
Olecranon, fracture, undisplaced, anterior dislocation of head of radius associated with, in children, 508.
Oligodactyly, 752.
Orthopaedic surgeons, honours to (*editorial*), 784.
Os calcis, avulsion fracture of, 598.
osteotomy of, in treatment of pes cavus, 163.
Osteitis deformans, familial, dystrophia myotonica associated with, with sarcomata, 316.
pubis after inguinal herniorrhaphy (*demonstration*), 592.
arthritis of hip complicating, 701.
Osteochondritis dissecans, 159; (*editorial*), 219.
in association with dwarfism, 261.
of hip, 268.
knee, bilateral (*demonstration*), 592.
treatment of, 248.
of thoracic spine, sacroiliitis condensans and ankylosing spondylitis, 582.
Osteoclasts, intravascular, 346.
Osteodystrophy of skull and face, familial, 313.
Osteogenesis imperfecta (*demonstration*), 598.
histological and microradiographic study of, 786.
radiological aspects of, 786.
symposium on, 786.
Osteoma, osteoid, osteosclerosis of tibia simulating (*demonstration*), 157.
Osteomalacia, insensitivity to calciferol developing during treatment of, 422.
Osteomyelitis (*demonstrations*), 597.
acute, in infants, 793.
chronic, delayed primary closure following sequestrectomy in, 779.
of spine, pyogenic, 798.
sclerosing, 790.
Oxford, Nuffield Orthopaedic Centre lectures, 156.

P

Paget's disease, familial, dystrophia myotonica associated with, with sarcomata, 316.
of bone, 797.
Pain of cervical origin, 157.
referred, some aspects of, 790.
Palmar flap, 80.
Palsy, cerebral, spasticity during sleep in children with, 599.
posterior interosseous nerve (*demonstration*), 593.
Paraplegia from spinal cord injuries and diseases, treatment and rehabilitation of patients, 600.
partial, due to bone tumour (*demonstration*), 593.
Patella, dislocation, recurrent, 798.
Pectoralis minor transplant, replacement of biceps brachii by, 126, 156.
Peripheral vascular failure, senile, 594.
Perthes' disease, 594, 790; (*demonstration*), 597.
treatment of, 782.
Pes cavus, idiopathic etiology of, 585.
osteotomy of calcaneum in treatment of, 163.
valgus, Grice's operation for, 596.
Plaster-of-Paris bandages, clinical and experimental study of, 793.
Poliomyelitis, old, contracture of tensor fasciae latae in, 595.
short leg in, 781.
vaccination, field studies, 583.
live virus, 584.
vaccine, preparation and testing of, 583.
Pott's disease in children, 798.
Prosthesis for tetraplegics, 132.
simple, for rural amputees, 131.
Pseudarthrosis, experimental, " petals " versus bony transplants in treatment of, 799.
Pseudohypoparathyroidism, 39.
Putti, V., and Robert Jones, tributes to, 423.

Q

Quadricepsplasty (*demonstration*), 597.

R

Radial nerve in osseous tunnel at humeral fracture site diagnosed radiographically, 746.
Radioactive isotopes and bone, 780.
Radio-ulnar joint, inferior, subluxation of, complicating fracture of radial head, 278.
Radius, absence of, congenital (*demonstrations*), 157, 596.
dislocation of head of, anterior, associated with undisplaced fracture of olecranon in children, 508.
congenital, 86.
fracture of head of, complicated by subluxation of inferior radio-ulnar joint, 278.
remodelling of lower epiphysis after fracture separation (*demonstration*), 790.
Reed longitudinal osteotomy of tibia, 738.
Rheumatoid arthritis presenting as tenosynovitis, 288.
Rickets, metabolic, insensitivity to calciferol developing during treatment of various forms of, 422.
Robert Jones Centenary meeting, 579.
Volume, 179.
Dining Club dinner at Liverpool, 590.
Golf Competition, 1957, 590.

S

Sacro-iliac joint, surgical approach to, 783.
Sacroiliitis condensans, osteochondritis of thoracic spine, and ankylosing spondylitis, 582.
Sarcoma, multifocal osteogenic, 524.
osteogenic, of femur, 597.
Sarcomata, dystrophia myotonica associated with familial Paget's disease with, 316.
Scaphoid bone, fracture of, comminuted (*demonstration*), 788.
Scapula, aneurysmal bone cyst, subtotal removal of scapula for, 128.
Scheuermann's disease, sacroiliitis condensans, and ankylosing spondylitis, 582.
Sciatica, clinical assessment of, 798.
relief of (*demonstration*), 598.
Scoliosis (*demonstration*), 596.
Buschenfeldt's corset in treatment of, 599.
management of, 162.
movements of spine with reference to, 579.
spinal fusion for, results of, 579.
Shoulder, dislocation, anterior, recurrent, 795.
complicated by complete rupture of axillary artery; successful suture of artery, 714.
of acromio-clavicular joint, chronic, method of repairing, 798.
posterior, 726.
anatomy of, 579.
recurrent, 164.
Bankart's operation for, 114.
pain, 594.

Skull and face, familial osteodystrophy of, 313.
Smith's fracture, reduction of, 463.
South African Orthopaedic Association, fifth Congress, 1956, 159.
South-East Metropolitan Region Orthopaedic Club, meeting, Nov. 1956, 156.
Feb. 1957, 592.
May 1957, 787.
South-West Orthopaedic Club, meeting, Nov. 1956, 157.
May 1957, 788.
Spinal cord injuries and diseases, paraplegia from, treatment and rehabilitation of patients, 600.
incomplete, with Brown-Séquard phenomena, 438.
Spine, cervical, cineradiography of (*film*), 585.
dislocation, spontaneous (*demonstration*), 596.
fracture-dislocation of, 23.
injuries to, 794.
manipulation, simple traction harness for, 756.
chondroblastoma of, 705.
fusion for scoliosis, results of, 579.
in tuberculosis, 594.
intervertebral disc lesions, cervical, pain due to, 157.
lumbar, role of abdominal pressure in relieving pressure on, 718.
physiology, mechanics of, as related to early stages of degeneration, 796.
lumbar, fracture-dislocation of, 742.
movements of, 339.
vertebrae, primary instability of, as common cause of low back pain, 6.
normal and abnormal movements of, with special reference to scoliosis, 579.
osteomyelitis, pyogenic, 798.
scoliosis (*demonstration*), 596.
Buschenfeldt's corset in treatment of, 599.
management of, 162.
movements of spine with reference to, 579.
results of fusion for, 579.
osteochondritis of, sacroiliitis condensans and ankylosing spondylitis, 582.
Spondylitis, ankylosing, osteochondritis of thoracic spine and sacroiliitis condensans, 582.
spontaneous atlanto-axial dislocation complicating, 582.
Spondylolisthesis in children, 797.
traumatic, aneurysm complicating, 498.
Sternum, flexion-compression injury of, 487.
Sweat gland tumour of hand, 102.

T

Talus, congenital vertical, 580.
fracture-dislocation of body of, 799.
fractured neck of (*demonstration*), 597.
fusions about, in children, 798.
Tenosynovitis of flexor tendons of hand (*demonstration*), 157.
rheumatoid arthritis presenting as, 288.
tuberculous, 91.
Tensor fasciae latae, contracture of, in old poliomyelitis, 585.
Tetanus following McMurray osteotomy for osteoarthritis of hip, 787.
Tetraplegia, complete, 157.
Tetraplegics, improvement of hand function in, 791.
prosthesis for, 132.
Thenar flap, 80.
muscles, maldevelopment of certain, congenital development of carpus associated with, 458.
Thigh, neoplasm in (*demonstration*), 594.
Thomas, Hugh Owen (*portrait*), 180.
Thumb and radius, congenital absence of (*demonstration*), 596.
Thyroid hormone, effect on embryonic development, 164.
Tibia, blood supply of, 799.
congenital varus deformity of, treated by osteotomy-osteoclasis (*demonstration*), 157.
fracture, complications of internal fixaton of, 595.
fatigue, and of fibula in same leg, 302.
severe compound, amputation in relation to (*discussion*), 158.
stress, in athletes, 783.
ununited, Charnley compression for (*demonstration*), 593.
longitudinal osteotomy of, 738.
osteoid osteoma of (*demonstration*), 787.
osteomyelitis of, 423.
osteosclerosis of, simulating osteoid osteoma (*demonstration*), 157.
Tibialis posterior, use as a dorsiflexor, 674.
Tissue culture as tool in dental research, 591.
Toes, claw, fixed, surgery of, 585.
Tooth germs, experimental embryology of, 591.
Travelling Fellows, American and Canadian, visit of, to Britain, 784.
Trueta, J., Brazilian honour for, 784.
Tuberculosis of hip, partial synovectomy and curettage in treatment of, 66.
orthopaedic (*symposium*), 160.
domiciliary treatment of, 161.
skeletal, local therapy in, 161.
treatment of sinuses and abscesses, 326.
treatment, recent trends in, 161.
Tumours, malignant (*demonstrations*), 797.
primary osteogenic, of skeleton, 157.

U

Ulnar neuritis, tardy, surgical treatment of, 782.

V

Vertebrae, lumbar, movements of, 339.
primary instability of, as common cause of low back pain, 6.
Volkmann's ischaemic contracture, threatened, relief of traumatic arterial spasm in, 711.

W

Wrist, fracture, Colles's, malunited, 164.
Smith's, reduction of, 463.
subluxation of inferior radio-ulnar joint complicating fracture of radial head, 278.
Wrists, both, congenital fusion of greater multangular and navicular bones of carpus of (*demonstration*), 157.

X

X-rays, gonadal protection against (*demonstration*), 598.

CONTRIBUTORS—NOVEMBER 1957

G. P. ARDEN, Esq., F.R.C.S., 1 Dorset Road, Windsor, Berkshire, England.

J. N. ASTON, Esq., F.R.C.S., The Orthopaedic Department, St Bartholomew's Hospital, London, E.C.1, England.

Professor D. L. BARTELINK, M.D., Research-Professor of Radiological Anatomy, Medical School, University of Western Ontario, London, Ontario, Canada.

A. BENJAMIN, Esq., F.R.C.S., Charing Cross Hospital, London, W.C. 2, England.

JOHN P. BLANDY, Esq., F.R.C.S., King George V Hospital, Ilford, Essex, England.

J. G. BONNIN, Esq., F.R.C.S., 51 Harley Street, London, W. 1, England.

Dr JANUSZ BURACZEWSKI, M.D., Institute of Oncology, Warsaw, Poland.

Dr MARTIN BURGER, M.S., Department of Biochemistry, Jewish Hospital of Brooklyn, 555 Prospect Place, Brooklyn 38, N.Y., United States of America.

H. JACKSON BURROWS, Esq., M.D., F.R.C.S., 25 Upper Wimpole Street, London, W. 1, England.

R. W. BUTLER, Esq., M.D., F.R.C.S., 11 Grange Road, Cambridge, England.

R. A. DENHAM, Esq., F.R.C.S., Round Hill House, Old Woking Road, Surrey, England.

H. L. DUTHIE, Esq., F.R.C.S.Ed., F.R.C.S., Western Infirmary, Glasgow, W. 1, Scotland.

Major ROBERT FULLER, M.R.C.S., L.R.C.P., R.A.M.C., Cambridge Military Hospital, Aldershot, Hampshire, England.

D.LL. GRIFFITHS, Esq., *M.B.E.*, F.R.C.S., Department of Orthopaedic Surgery, The Royal Infirmary, Manchester 13, England.

D. R. GUNN, Esq., M.Ch.Orth., F.R.C.S.E., Department of Orthopaedic Surgery, University of Malaya, Singapore, Federation of Malaya.

Dr J. E. HALL, B.A., M.D., C.M., 728 Eglinton Avenue E., Toronto 17, Ontario, Canada.

Dr MEREDITH VAUGHAN JONES, M.B., Ch.B., "Y Betws," Port Dinorwic, North Wales.

Professor T. POMFRET KILNER, *C.B.E.*, F.R.C.S., The Nuffield Department of Plastic Surgery, The Churchill Hospital, Oxford, England.

Dr LEROY S. LAVINE, M.D., F.A.C.S., 2035 Lakeville Road, New Hyde Park, N.Y., United States of America.

W. ALEXANDER LAW, Esq., *O.B.E.*, M.D., F.R.C.S., 9 Queen Anne Street, London, W. 1, England.

Dr A. LEMOINE, M.D., 28 Avenue Mozart, Paris 16e, France.

Dr JANINA LYSAKOWSKA, M.D., Institute of Oncology, Warsaw, Poland.

H. B. COATES MILSOM, Esq., M.Ch.Orth., F.R.C.S., Wagstaff's Buildings, Cameron Road, Tauranga, New Zealand.

Dr D. B. MOLESWORTH, M.R.C.S., L.R.C.P., World Health Organisation, Geneva, Switzerland.

O. R. NICHOLSON, Esq., F.R.C.S., F.R.A.C.S., Middlemore Hospital, Auckland, New Zealand.

GEORGE PERKINS, Esq., *M.C.*, F.R.C.S., "Hilda," East Beach, Selsey, Sussex, England.

R. G. PULVERTAFT, Esq., F.R.C.S., 27 Friar Gate, Derby, England.

J. B. PYPER, Esq., F.R.C.S., Department of Orthopaedics, Royal Victoria Hospital, Belfast, Northern Ireland.

ROBERT ROAF, Esq., M.Ch.Orth., F.R.C.S., Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, Shropshire, England.

D. E. ROBERTSON, Esq., F.R.C.S.(E.), "Arosa," Melrose Road, Galashiels, Selkirkshire, Scotland.

Dr B. S. ROSE, M.R.C.P., D.C.H., Queen Elizabeth Hospital, Rotorua, New Zealand.

Dr WITOLD RUDOWSKI, M.D., Institute of Oncology, Warsaw, Poland.

J. C. SCOTT, Esq., M.D., M.S., F.R.C.S., Nuffield Orthopaedic Centre, Oxford, England.

Dr STUART SCOUGALL, M.D., 135 Macquarie Street, Sydney, Australia.

Dr H. A. SISSONS, M.B., B.S., Department of Pathology, The Institute of Orthopaedics, Royal National Orthopaedic Hospital, 234 Great Portland Street, London, W. 1, England.

Dr ALBERT E. SOBEL, Ph.D., Department of Biochemistry, Jewish Hospital of Brooklyn, 555 Prospect Place, Brooklyn 38, N.Y., United States of America.

E. W. SOMERVILLE, Esq., F.R.C.S.E., Nuffield Orthopaedic Centre, Oxford, England.

Dr BERTIL STENER, M.D., Kir. kliniken I, Sahlgrenska Sjukhuset, Gothenburg, Sweden.

F. G. ST CLAIR STRANGE, Esq., F.R.C.S., 10 New Dover Road, Canterbury, Kent, England.

DAVID TREVOR, Esq., M.S., F.R.C.S., 48 Wimpole Street, London, W. 1, England.

Dr W. J. WESTON, M.R.C.P.E., D.M.R.D., Hutt Hospital, Lower Hutt, New Zealand.

J. N. WILSON, Esq., F.R.C.S., The Chequers, Waterdale, nr. Watford, Hertfordshire, England.

d.
y

e,

re,
ter
a,

hill
ca.

nd.

nd.
try,

onal
lace,

GERY